

**BEAMBEPREP**

PAKISTAN ENTRANCE EXAMINATION ENGINE

**SCAN TO SOLVE LIVE**Timer, instant scoring, and
percentile ranks on
beambeprep.com

SZABMU ISLAMABAD

SZABMU Islamabad MDCAT 2025 Official Paper

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

📍 Official Admitting Board: Shaheed Zulfikar Ali Bhutto Medical University Islamabad 📄 Archive Code: BEAMBE-FLP-SZABMU-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

Which of the following hormones in the body of an animal is lipid-based in nature?

- (A) Insulin
- (B) FSH
- (C) Oxytocin
- (D) Aldosterone

Q2. BIO

Which of the following base pairings maintains the constant diameter of the DNA double helix as per Watson and Crick's model?

- (A) Purine - Purine
- (B) Pyrimidine - Pyrimidine
- (C) Purine - Pyrimidine
- (D) Sugar - Phosphate

Q3. BIO

Which muscle type is under conscious control and is multinucleated?

- (A) Smooth muscle
- (B) Skeletal muscle
- (C) Cardiac muscle
- (D) Visceral muscle

Q4. BIO

Which of the following connective tissues is completely avascular and heals slowly?

- (A) Bone
- (B) Cartilage
- (C) Adipose tissue
- (D) Areolar tissue

Q5. BIO

Cardiac muscles are different from skeletal muscles because they:

- (A) Lack striations
- (B) Are voluntary and multinucleated
- (C) Are involuntary and multinucleated
- (D) Are striated but involuntary

Q6. BIO

Which organelle gives rise to primary lysosomes through budding in eukaryotic cells?

- (A) Smooth endoplasmic reticulum (SER)
- (B) Rough endoplasmic reticulum (RER)
- (C) Plasma membrane
- (D) Golgi cisternae

Q7. BIO

A mutation prevents proper disulphide bond formation in a fibrous protein, causing brittle nails and slow hair growth. Which of the following proteinaceous substances would be affected?

- (A) Elastin
- (B) Actin
- (C) Keratin
- (D) Collagen

Q8. BIO

In muscle fibers, T-tubules are extensions of the sarcolemma that penetrate into the cell interior. What is their main function during muscle contraction?

- (A) Unblock actin's binding sites
- (B) Conduct nerve impulses deep into the muscle cell
- (C) Synthesize glycogen in the sarcoplasm
- (D) Store calcium ions in the sarcoplasmic reticulum

Q9. BIO

Polysaccharides such as starch and glycogen are mainly used for:

- (A) Structural framework only
- (B) Short-term and long-term energy storage
- (C) Enzyme catalysis
- (D) Ready source of energy

Q10. BIO

In chromosomes, positively charged histone proteins are organized with negatively charged DNA. The positive charges of histones are due to an abundance of basic amino acids:

- (A) Arginine and alanine
- (B) Arginine and lysine
- (C) Lysine and alanine
- (D) Phenylalanine and arginine

Q11. BIO

The envelope in a virus is derived from:

- (A) Host cell-ribosomes
- (B) Host cell membrane
- (C) Viral capsid proteins
- (D) Viral genome replication

Q12. BIO

The myelin sheath acts as an:

- (A) Protector
- (B) Insulator
- (C) Sensor
- (D) Supporter

Q13. BIO

DNA/RNA probes are most commonly used as:

- (A) Diagnostic tools of infectious diseases
- (B) Carrier or vector in gene cloning
- (C) Cementing material in somatic cell hybridization
- (D) Carrier or vector in gene therapy

Q14. BIO

The event that occurs first during skeletal muscle contraction?

- (A) Cross-bridge formation
- (B) Release of calcium from sarcoplasmic reticulum
- (C) Power stroke
- (D) Myosin head binds to ATP

Q15. BIO

When genes are linked, they tend to:

- (A) Segregate randomly
- (B) Cross over every time
- (C) Stay together during inheritance
- (D) Be inherited separately

Q16. BIO

According to Morgan's experiment, which of the following is essential for detecting gene linkage accurately?

- (A) Large number of progeny
- (B) Small sample size
- (C) Use of male flies only
- (D) Mutation induction

Q17. BIO

The end of skeletal muscle attached with moveable bone is:

- (A) Insertion
- (B) Origin
- (C) Tendons
- (D) Belly

Q18. BIO

Which of the following is common between aldosterone, sex hormones and cortisol?

- (A) They are peptides
- (B) They are phospholipids
- (C) They are steroids
- (D) They are glycoproteins

Q19. BIO

Which one of the following organism is uricotelic with reference to secretion of nitrogenous compound?

- (A) Human
- (B) Freshwater Fish
- (C) Snake
- (D) Frog

Q20. BIO

Ureotelism (removal of nitrogenous waste in the form of urea) is an adaptation to the:

- (A) Cold weather
- (B) Less availability of water
- (C) Flooded environmental conditions
- (D) Food shortage

Q21. BIO

All of the following are the characteristics of limbic system EXCEPT:

- (A) Produce most basic and primitive emotions and drives
- (B) Formation of memories
- (C) Consists of hypothalamus, amygdala, and hippocampus
- (D) Controls reflex movement of eyes

Q22. BIO

Sensory input from auditory and visual pathways, skin and within the body is received by _____ and distributed to

- (A) Hypothalamus; Cerebellum
- (B) Thalamus; cerebrum
- (C) Cerebrum; rest of the brain
- (D) Cerebellum; rest of the brain

Q23. BIO

According to the Lamarck theory of evolution, the organ that has not been used in several generations will:

- (A) Become strong
- (B) Get amputated
- (C) Disappear
- (D) Become developed

Q24. BIO

Which of the following statement is incorrect with reference to the enzyme action?

- (A) Substrate binds with the enzyme at its active site
- (B) Non-competitive inhibitor binds the enzyme at a site distinct from that of active site
- (C) Addition of a lot of succinate do not reverse the inhibition of succinic dehydrogenase by malonate
- (D) Malonate is a competitive inhibitor of succinic dehydrogenase

Q25. BIO

The temperature of underground water remains constant due to:

- (A) Heat capacity
- (B) Polarity of water
- (C) Heat of vaporization
- (D) Specific heat of vaporization

Q26. BIO

The shape of adenovirus is:

- (A) Helical shape
- (B) Tadpole shape
- (C) Polyhedron shape
- (D) Circular shape

Q27. BIO

In human female normally ovulation occurs at _____ day of menstrual cycle.

- (A) 9
- (B) 11
- (C) 14
- (D) 15

Q28. BIO

HIV belongs to which class of virus with respect to genome type?

- (A) Single stranded DNA viruses
- (B) Double stranded RNA viruses
- (C) ssRNA; template for DNA synthesis
- (D) ssRNA; template for mRNA synthesis

Q29. BIO

How many ATPs are produced during oxidative phase of glycolysis?

- (A) 2
- (B) 4
- (C) 34
- (D) 36

Q30. BIO

Which of the following best describes the relationship between endoplasmic reticulum (ER) and Golgi apparatus?

- (A) Both ER and Golgi apparatus are completely separate organelles with no interaction
- (B) ER is precursor organelle to Golgi apparatus because material is transported from ER to Golgi
- (C) Golgi apparatus is precursor organelle to ER because material is transported from Golgi to ER
- (D) ER and Golgi apparatus have similar roles

Q31. BIO

Osmotic gradient of inner medulla of kidney is increased by:

- (A) Urea
- (B) Water
- (C) Phosphate
- (D) Potassium

Q32. BIO

Decreased level of FSH hormone during menstrual cycle triggers release of:

- (A) hcg
- (B) LH
- (C) Oxytocin
- (D) Progesterone

Q33. BIO

The digestive secretions from different parts of GIT have the ability to kill microbe present in the food. Which of the following best describe this role?

- (A) Antiseptics
- (B) Disinfectants
- (C) Chemotherapeutics
- (D) Immunosuppressant

Q34. BIO

A carrier female for hemophilia can pass the defective allele to:

- (A) Only sons
- (B) Only daughters
- (C) Both sons and daughters
- (D) Neither sons nor daughters

Q35. BIO

During ventricular systole, which pressure changes occur?

- (A) Ventricular pressure rises above atrial and arterial pressure
- (B) Atrial pressure rises above Ventricular pressure
- (C) Ventricular pressure falls below arterial pressures
- (D) Ventricular pressure falls below Atrial pressure

Q36. BIO

Which cell type is essential for stimulating cell division of both B-cells and T-cells?

- (A) Plasma cells
- (B) Memory cells
- (C) Helper T-cells
- (D) Neutrophils

Q37. BIO

The hormone, when overproduced can lead to hypercalcemia and stone formation is

- (A) Insulin
- (B) Thyroxine
- (C) Parathyroid hormone
- (D) Calcitonin hormone

Q38. BIO

Fibrocartilage is found in:

- (A) Trachea
- (B) Nose
- (C) Knee joint
- (D) Ear flaps

Q39. BIO

Additional capillaries present in the juxtamedullary nephrons to form a loop of vessels are:

- (A) Efferent arterioles
- (B) Peritubular capillaries
- (C) Vasa recta
- (D) Afferent arterioles

Q40. BIO

Y-linked inheritance refers to which mode of the inheritance?

- (A) Crisscross
- (B) Straight
- (C) Loop
- (D) Jumping

Q41. BIO

If a colorblind lady marries a normal man, their children will be:

- (A) Normal daughters and normal sons
- (B) Normal sons and carrier daughters
- (C) Colorblind sons and carrier daughters
- (D) Colorblind sons and colorblind daughters

Q42. BIO

All of the following properties of water are associated with its capillary action. EXCEPT:

- (A) Adhesion
- (B) Density
- (C) Cohesion
- (D) Surface tension

Q43. BIO

Which organelle serves as a packaging and a distribution center for molecules within the cells?

- (A) Golgi apparatus
- (B) Mitochondria
- (C) Ribosome
- (D) Vacuole

Q44. BIO

Which of the following hormone is not produced in older women?

- (A) Estrogen
- (B) Gastrin
- (C) Secretin
- (D) Renin

Q45. BIO

Which lymphatic structure absorbs dietary fats in the intestine?

- (A) Peyer's patches
- (B) Lacteals in villi
- (C) Pancreatic duct
- (D) Lymph nodes

Q46. BIO

Thinking, memory and voluntary actions are mainly controlled by the:

- (A) Cerebrum
- (B) Cerebellum
- (C) Pons
- (D) Hippocampus

Q47. BIO

Ventricular diastole causes:

- (A) Ventricular contraction
- (B) Closure of atrioventricular valves
- (C) Opening of semilunar valves
- (D) Closure of semilunar valves

Q48. BIO

Which of the following statements correctly describes the organelle that is not membrane bound?

- (A) Presence of cristae
- (B) Modification and packaging of proteins
- (C) Presence of digestive enzymes
- (D) Made of rRNA and protein

Q49. BIO

A biological laboratory is developing gene therapy with a modified virus that infects birds only. Which of the following categories does this virus belong to?

- (A) Algal virus
- (B) Fungal virus
- (C) Animal virus
- (D) Bacterial virus

Q50. BIO

CFTR gene that encodes a protein which regulates:

- (A) Protein and salt
- (B) Salt and Water
- (C) Sugar and Water
- (D) Liquid and Protein

Q51. BIO

Which organelle is usually referred as post office of the cell and why?

- (A) Golgi apparatus, because it receives, sorts and packages material for transport to other parts of cell
- (B) Rough endoplasmic reticulum, because it synthesizes protein used by the cell
- (C) Mitochondria, because it synthesizes and provides energy to other parts of the cells
- (D) Nucleus, because it controls other organelles of the cell

Q52. BIO

Components of reflex arc must contain neurons from:

- (A) Motor nerve and Mixed nerve
- (B) Sensory nerve and Intermediate nerve
- (C) Motor nerve and Sensory Nerve
- (D) Mixed nerve and Intermediate nerve

Q53. BIO

A confirmed COVID patient shows weak specific immunity. Which component is most likely deficient in this patient?

- (A) Red Blood Cells
- (B) Helper T-Lymphocytes
- (C) Thrombocytes
- (D) Suppressor T-Lymphocytes

Q54. BIO

Which of the following organ takes part in the T-cell maturation for both the lymphatic and endocrine systems?

- (A) Spleen
- (B) Thymus
- (C) Liver
- (D) Kidney

Q55. BIO

The part of male reproductive system that maintains the temperature for sperm production is:

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

Q56. BIO

After Liver transplant, doctors suppress the T-lymphocyte activity in patient. Why?

- (A) To increase the rate of antibody production
- (B) To prevent infections
- (C) To avoid graft rejection by the immune system
- (D) To produce memory cells faster

Q57. BIO

How do the kidneys contribute to maintain normal blood calcium level?

- (A) By storing excess calcium
- (B) By reabsorbing calcium and activating vitamin D
- (C) By secreting calcium directly into the blood
- (D) By converting calcium into urea for excretion

Q58. BIO

Nodes of Ranvier along the length of axon fibers allow:

- (A) More diffusion of neurotransmitters
- (B) Saltatory conduction of nerve impulse
- (C) Formation of new synaptic connections
- (D) Synthesis of new neurons

Q59. BIO

Arachidonic acid, which is the precursor molecule for prostaglandins is:

- (A) saturated fatty acid with 18 carbons
- (B) An unsaturated fatty acid with 18 carbons
- (C) A tri-unsaturated fatty acid with 20 carbons
- (D) A tetra-unsaturated fatty acid with 20 carbons

Q60. BIO

Atrial walls are thinner as compared to ventricles because:

- (A) Atria are small in size
- (B) Atria are present above the ventricles
- (C) Atria have to force blood into the ventricles which lie very close to them
- (D) Blood enters into the atria by osmosis

Q61. BIO

A patient with a genetic disorder undergoes treatment where a normal gene is inserted into their cells. This is called:

- (A) Gene therapy
- (B) Genetic testing
- (C) Protein engineering
- (D) DNA fingerprinting

Q62. BIO

Which of the following is not a potential symptom of chronic renal failure?

- (A) Nephritis and bacterial infection
- (B) Bone pain and fractures
- (C) Impaired concentration and confusion
- (D) Muscle cramps due to electrolyte imbalance

Q63. BIO

Arthritis is a disease that primarily affects the:

- (A) Kidneys
- (B) Lungs
- (C) Joints
- (D) Muscles

Q64. BIO

Osmoreceptors that detect the osmotic pressure of blood are primarily located in the:

- (A) Hypothalamus
- (B) Cerebellum
- (C) Medulla oblongata
- (D) Cerebral cortex

Q65. BIO

A chromosome which contains the centromere at the center is called:

- (A) Mesocentric chromosome
- (B) Metacentric chromosome
- (C) Acrocentric chromosome
- (D) Telocentric chromosome

Q66. BIO

Binding site for a substrate on enzyme is:

- (A) Allosteric site
- (B) Passive site
- (C) Active site
- (D) Regulatory site

Q67. BIO

The most abundant polysaccharide in plants, widely used in paper and as a source of dietary fibre for human is:

- (A) Chitin
- (B) Glycogen
- (C) Starch
- (D) Cellulose

Q68. BIO

This given organelle is involved in the synthesis of oil, phospholipids and steroids:

- (A) Mitochondria
- (B) Golgi complex
- (C) Endoplasmic reticulum
- (D) Ribosomes

Q69. BIO

Which type of neurons stimulate the muscles to contract in a reflex arc?

- (A) Efferent neurons
- (B) Sensory neurons
- (C) Interneurons
- (D) Afferent neurons

Q70. BIO

Receptors that are located in the retina of eye are called:

- (A) Merkel disc
- (B) Ruffini endings
- (C) Pacinian corpuscles
- (D) Rod and Cone cells

Q71. BIO

The bony roof of the oral cavity, which separates it from the nasal cavity, is formed by the:

- (A) soft palate
- (B) Mandible
- (C) Hard palate
- (D) Maxilla

Q72. BIO

Which structure in neuron is responsible for receiving information from other neurons?

- (A) Axon
- (B) Soma
- (C) Dendrite
- (D) Axon terminal

Q73. BIO

Chemicals that stimulate the olfactory receptors enter the nasal cavity in the form of

- (A) solid
- (B) liquid
- (C) gas
- (D) plasma

Q74. BIO

Neurosecretory cells are:

- (A) Endocrine cells
- (B) Exocrine cells
- (C) Coneuroglial cells
- (D) Neurons that have been adapted to secrete hormones

Q75. BIO

Lamarck theory of evolution was rejected experimentally by:

- (A) JA. Earnest Hackle
- (B) Charles Darwin
- (C) August Weismann
- (D) Thomas R. Malthus

Q76. BIO

Which of the following characteristics is common among sucrose, lactose and maltose?

- (A) molecular formula
- (B) occurrence in living beings
- (C) chemical nature of their monosaccharide units
- (D) to act as reducing sugar

Q77. BIO

Ribozymes are the only biocatalysts that are made up of:

- (A) DNA
- (B) RNA
- (C) Protein
- (D) Fatty acid

Q78. BIO

The induced fit model differs from the Lock and Key model because the enzyme in this model:

- (A) Has a rigid and fixed active site
- (B) Changes shape to fit the substrate
- (C) Is non-specific in its action
- (D) Is denatured during reaction

Q79. BIO

Which competitive inhibitor blocks the enzyme responsible for bacterial cell wall synthesis?

- (A) Sulphonamide
- (B) Streptomycin
- (C) Tetracycline
- (D) Penicillin

Q80. BIO

Water commonly known as a universal solvent because:

- (A) It dissolves polar and ionic substances effectively
- (B) It supports chemical reactions without reacting itself
- (C) It has a high specific heat capacity
- (D) It dissolves many substances due to its small molecule size

Q81. BIO

Which of the following structural change in water molecule leads to the low density of ice?

- (A) Formation of ionic bonds
- (B) Expansion due to hydrogen bonding
- (C) Increased kinetic energy
- (D) Loss of polarity in molecules

CHEM SECTION: CHEMISTRY

Questions 82 to 126 (45 MCQs)

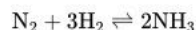
Q82. CHEM

Reduction of carboxylic acid by using lithium aluminohydride produce

- (A) Alcohol
- (B) Acid halide
- (C) Ester
- (D) Alkane

Q83. CHEM

In separate vessel of volume 2000 cm³ and 1500cm³, 6g of hydrogen and 28g of nitrogen are mixed in each vessel at 25°C, ammonia formed is?



- (A) More in 2 L vessel
- (B) More in 1500 cm³ vessel
- (C) Equal in both vessel
- (D) Cannot be predicted

Q84. CHEM

The weakest intermolecular force present in liquid is?

- (A) Dipole dipole forces
- (B) Induced dipole force
- (C) Instantaneous dipole induced dipole force
- (D) Hydrogen bonding

Q85. CHEM

Number of sigma bond in acetylene and ethylene are?

- (A) 3 & 5
- (B) 3 & 3
- (C) 6 & 5
- (D) 5 & 6

Q86. CHEM

Which of the following has smallest bond angle?

- (A) C₂H₂
- (B) NH₃
- (C) H₂S
- (D) BeCl₂

Q87. CHEM

Which one of the following has highest ionic character?

- (A) AlCl₃
- (B) BCl₃
- (C) PCl₃
- (D) NaH

Q88. CHEM

Which one has highest bond energy?

- (A) sp-s
- (B) sp³-s
- (C) sp²-s
- (D) sp³-p

Q89. CHEM

The relationship of (+) tartaric acid and (-) Tartaric acid are:

- (A) Geometric isomers
- (B) Enantiomers
- (C) Diastereomers
- (D) Planar

Q90. CHEM

The IUPAC name of compound C₆H₅COCH₃ is:

- (A) methylphenylketone
- (B) phenylethanone
- (C) octan-2-one
- (D) benzylethanone

Q91. CHEM

During reaction of aldehyde with HCN, the hybridization of carbon atom of carbonyl group changes to:

- (A) sp to sp²
- (B) sp³ to sp²
- (C) sp² to sp³
- (D) dsp² to sp³

Q92. CHEM

Acetone reacts with water in presence of catalyst produces:

- (A) propan-2-ol
- (B) propan-1,2-diol
- (C) propan-2,2-diol
- (D) propanol

Q93. CHEM

Which one show positive test with Fehling solution:

- (A) Acetophenone
- (B) Metaformaldehyde
- (C) Acetaldehyde
- (D) Benzaldehyde

Q94. CHEM

Oxidation state of Tungsten in Na₂W₄O₁₃·H₂O is:

- (A) +5
- (B) +6
- (C) +8
- (D) Zero

Q95. CHEM

Orientation of reacting molecules is important in collision theory in the following cases EXCEPT:

- (A) High Pressure
- (B) Complex molecules
- (C) Polyatomic molecules
- (D) Low pressure

Q96. CHEM

Keeping temperature constant, if pressure is increased, density of gas will:

- (A) Increases
- (B) Decreases
- (C) Gets doubled
- (D) Remains same

Q97. CHEM

IUPAC name of chloroform is:

- (A) Methylchloride
- (B) Methyltrichloride
- (C) Trichloromethane
- (D) Chloromethane

Q98. CHEM

Which among the following will react with ammonical cuprous chloride:

- (A) 1-butene
- (B) 1-butyne
- (C) 2-butene
- (D) 2-butyne

Q99. CHEM

Which of the following is not a crystalline solid?

- (A) KCl
- (B) Fe metal
- (C) Glass
- (D) Rhombic S

Q100. CHEM

Number of electron with $l=2$ in an atom having atomic number 23 is:

- (A) 2
- (B) 3
- (C) 4
- (D) 5

Q101. CHEM

Reaction having high activation energy are:

- (A) Spontaneous
- (B) Fast
- (C) Slow
- (D) Always exothermic

Q102. CHEM

Which of the following reagents is used to convert benzene to 2-chloro methyl benzene?

- (A) $\text{CH}_3\text{Cl}/\text{AlCl}_3$ followed by Cl_2 in the presence of anhydrous FeCl_3
- (B) $\text{CH}_3\text{Cl}/\text{AlCl}_3$ followed by Cl_2 in the presence of diffused sunlight
- (C) $\text{Cl}_2/\text{FeCl}_3$ followed by CH_3Cl in the presence of diffused sunlight
- (D) Cl_2/UV followed by CH_3Cl in the presence of anhydrous FeCl_3

Q103. CHEM

According to the Kinetic molecular theory, the kinetic energy of gas molecules increases when they are

- (A) Melted from solid to liquid state
- (B) Mixed with other molecules at lower temperature
- (C) Frozen into solids
- (D) Condensed into liquids

Q104. CHEM

If the equilibrium expression of a reversible reaction is $\frac{[\text{C}]^2}{[\text{A}][\text{B}]}$. The balanced chemical equation should be:

- (A) $\text{C} \rightleftharpoons \text{A} + \text{B}$
- (B) $2\text{C} \rightleftharpoons \text{A} + \text{B}$
- (C) $\text{A} + \text{B} \rightleftharpoons \text{C}$
- (D) $\text{A} + \text{B} \rightleftharpoons 2\text{C}$

Q105. CHEM

Common name of 1,3 benzene diol is:

- (A) Pyrogallol
- (B) Cresol
- (C) Resorcinol
- (D) Catechol

Q106. CHEM

How many sigma and pi bonds are present in maleic anhydride?

- (A) 5 sigma 3 pi
- (B) 6 sigma 3 pi
- (C) 9 sigma 3 pi
- (D) 10 sigma 3 pi

Q107. CHEM

Addition of three molecules of chlorine into benzene prove that benzene has

- (A) 3 double bonds
- (B) Non polar
- (C) Polar
- (D) Non planar

Q108. CHEM

Propyne is allowed to react with hydrochloric acid two times then final product is

- (A) 1,1-dichloropropane
- (B) 1,2-dichloropropane
- (C) 2,2-dichloropropane
- (D) 1,2-dichloropropene

Q109. CHEM

Diethyl ether and Methyl n-propyl ether are

- (A) Position isomers
- (B) Functional group isomers
- (C) Metamers
- (D) Tautomer

Q110. CHEM

In the given reaction $\text{CH}_3\text{OH} \rightarrow \text{HCOOH}$, oxidation state of carbon changes from:

- (A) -2 to 0
- (B) -2 to +2
- (C) -3 to +2
- (D) 0 to +2

Q111. CHEM

For endothermic reaction, enthalpy change is:

- (A) $\Delta H_{\text{reactant}} > \Delta H_{\text{product}}$
- (B) $\Delta H_{\text{reactant}} < \Delta H_{\text{product}}$
- (C) $\Delta H_{\text{reactant}} = \Delta H_{\text{product}}$
- (D) $\Delta H_{\text{reactant}} = \Delta H_{\text{product}} = 0$

Q112. CHEM

The structure of four Chloroalkanes W, X, Y and Z are shown:

W: $(\text{CH}_3)_2\text{CHCH}(\text{Cl})\text{CH}_3$

X: $\text{CH}_2(\text{Cl})\text{CH}_3$

Y: $(\text{CH}_3)_3\text{CCH}_2\text{Cl}$

Z: $(\text{CH}_3)_2\text{CHC}(\text{CH}_3)_2\text{Cl}$

Select the Chloroalkane classified as tertiary:

- (A) W only
- (B) X only
- (C) Y only
- (D) Z only

Q113. CHEM

The smallest repeating pattern from which the lattice is built in a crystalline solid is called

- (A) Crystallite
- (B) Amorphous region
- (C) Unit cell
- (D) Crystal lattice

Q114. CHEM

Which of the following reaction will move backward by decreasing pressure?

- (A) $4\text{Q} \rightleftharpoons \text{T} + \text{S}$
- (B) $2\text{A} \rightleftharpoons 3\text{C}$
- (C) $\text{K} \rightleftharpoons \text{L}$
- (D) $\text{H} + 2\text{M} \rightleftharpoons 2\text{B} + 2\text{D}$

Q115. CHEM

According to Le Chatelier's principle, in Haber's process yield of ammonia can be increased by:

- (A) Decreasing pressure and increasing temperature
- (B) Increasing pressure and decreasing temperature
- (C) Increasing volume and decreasing temperature
- (D) Decreasing concentration of H_2

Q116. CHEM

Hyperbola isotherm is obtained when graph is plotted between:

- (A) P and $1/V$
- (B) PV and V
- (C) P and V
- (D) V and $1/P$

Q117. CHEM

Highest energy for one quantum among radiation is:

- (A) Microwave
- (B) Infrared
- (C) Ultra violet
- (D) Visible

Q118. CHEM

Which of the following reagent is commonly used to prepare alkyne from vicinal dihalide?

- (A) H_2 and catalyst
- (B) KOH/NaNH_2
- (C) KMnO_4
- (D) LiAlH_4

Q119. CHEM

In a standard hydrogen electrode, the platinum electrode:

- (A) Reacts with hydrogen
- (B) Provides a surface for oxidation and reduction
- (C) Acts as a salt bridge
- (D) Provides voltage to the circuit

Q120. CHEM

Which of the following compound has lower Lattice Energy?

- (A) LiCl
- (B) KCl
- (C) CaCl_2
- (D) $\text{C}_6\text{H}_{12}\text{O}$

Q121. CHEM

Reaction of 2-Bromobutane with alcoholic KOH yields:

- (A) 2-Butanol
- (B) 2-Butene
- (C) 2-Butyne
- (D) 1-Butanol

Q122. CHEM

Which species contain an element with an oxidation number of +4?

- (A) CrO_4^{2-}
- (B) MnO_4^{2-}
- (C) H_2SO_4
- (D) Na_2CO_3

Q123. CHEM

The rate of reaction for a zero-order reaction:

- (A) Increases as the reaction proceeds
- (B) Decreases as the reaction proceeds
- (C) Remains the same as the reaction proceeds
- (D) May decrease or increase as the reaction proceeds

Q124. CHEM

The order of chemical reaction is defined as:

- (A) The number of reactants involved in balanced equation
- (B) The number of products formed in balanced equation
- (C) The power to which the concentration of a reactant is raised in the rate equation
- (D) The rate constant of the reaction

Q125. CHEM

Real gases show more positive deviation as pressure increases because of

- Ⓐ Ionic nature
- Ⓑ Repulsive force
- Ⓒ Attractive forces
- Ⓓ Non polar nature

Q126. CHEM

Which statement applies to both ideal and real gases

- Ⓐ Collision between molecules are elastic
- Ⓑ Molecules are in constant random motion
- Ⓒ Molecules attract each other
- Ⓓ Molecules have zero size

PHY SECTION: PHYSICS

Questions 127 to 162 (36 MCQs)

Q127. PHY

If voltage across a resistor is doubled then its resistance will become: (temperature and physical state of the conductor remains constant).

- (A) Doubled
- (B) Half
- (C) Four Times
- (D) Remains Constant

Q128. PHY

A particle is moving in a uniform circular path whose projection is executing simple harmonic motion on horizontal diameter. The ratio of instantaneous velocity to the maximum velocity of the projection while passing through the center is:

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

Q129. PHY

The option that shows the conditions used by Laplace for connecting the velocity of sound is options medium used thermodynamics process

1 solid adiabatic 2 liquids isobaric 3 gas adiabatic 4 gas isothermal

- (A) 1 solid adiabatic
- (B) 2 liquids isobaric
- (C) 3 gas adiabatic
- (D) 4 gas isothermal

Q130. PHY

If different colored light beams have same total energy, which color beam will contain the smallest number of photons?

- (A) Violet
- (B) Blue
- (C) Green
- (D) Red

Q131. PHY

A patient is injected with a radioactive isotope to trace blood flow and detect circulation issues. The isotope used is more likely to be:

- (A) Iodine-131
- (B) Phosphorus-32
- (C) Cobalt-60
- (D) Sodium-24

Q132. PHY

Water flows through a pipe of 0.02 m² with a speed of 3 m/s. The pipe narrows to 0.01 m². The speed in narrower section is:

- (A) 1.5 m/s
- (B) 3 m/s
- (C) 6 m/s
- (D) 9 m/s

Q133. PHY

In the human circulatory system, turbulent blood flow is most likely to occur when the:

- (A) Vessel diameter is very small
- (B) Velocity of blood is very low
- (C) Blood flows through a clogged vessel
- (D) Blood viscosity increases

Q134. PHY

A conducting ring is placed near a current-carrying coil. As the current in the coil increases, the induced current in the ring flows:

- (A) In the direction of magnetic field
- (B) To increase the magnetic flux
- (C) To oppose increasing magnetic flux
- (D) Randomly without a definite direction

Q135. PHY

In progressive waves, energy is transferred from one point to another through:

- (A) Circular motion of particles
- (B) Oscillatory motion of particles
- (C) Rotation of particles
- (D) Translation of particles

Q136. PHY

A capacitor is connected to an ac source. If the frequency of the AC source is doubled the current in a purely capacitive circuit will:

- (A) Be doubled
- (B) Remains Unchanged
- (C) Become Half
- (D) Becomes zero

Q137. PHY

When thermal energy is transferred from a hot object to a cold one, the change occurs in the hot object as:

- (A) Increases in internal energy
- (B) Decrease in internal energy
- (C) Increase in temperature
- (D) Increase in heat content

Q138. PHY

Two spectral lines in the Hydrogen atom spectrum are close together. This likely means:

- (A) The energy difference is zero
- (B) The energy difference is small
- (C) The light intensity is low
- (D) The atom becomes unstable

Q139. PHY

When two identical waves arrive in phase at same point in a region at the same time the resultant displacement is equal to:

- (A) Displacement of a single wave
- (B) Difference of their displacements
- (C) Sum of their displacements
- (D) Product of their displacements

Q140. PHY

High slope of Ohm's law graph (V vs I) means:

- (A) Low resistance
- (B) High resistance
- (C) Open circuit
- (D) Low current

Q141. PHY

The electric potential at a point due to a point charge is 100 J/C. If a test charge of magnitude 1 C placed at that point is replaced with a 2 C charge, then the physical quantity that will change is:

- (A) Electric Field at that point
- (B) Electric potential at that point
- (C) Electric Potential Energy of the system
- (D) Temperature

Q142. PHY

The waves among the following which require a material medium for their propagation are:

- (A) Gamma rays
- (B) X-rays
- (C) Infrared waves
- (D) Infrasonic waves

Q143. PHY

Unequal-changes occurring in velocity of a body is called:

- (A) Uniform acceleration
- (B) Uniform velocity
- (C) Instantaneous acceleration
- (D) Variable acceleration

Q144. PHY

What will potential difference, if a wire has resistance of 10 ohms and current 2A flow through it:

- (A) 5V
- (B) 10V
- (C) 20V
- (D) 40V

Q145. PHY

According to the particle model of light, a photon is:

- (A) Particle with mass and charge
- (B) A quantum of energy with zero rest mass and zero charge
- (C) A continuous energy wave
- (D) A particle that travels slower than light

Q146. PHY

The current in forward biased PN junction is mainly due to:

- (A) Majority carriers
- (B) Minority carriers
- (C) leakage carrier
- (D) Thermionic emission

Q147. PHY

Stationary waves are formed in a stretched string of 2m length, such that two vibrating loops are formed. The distance between consecutive nodes formed is:

- (A) 0.5 m
- (B) 1 m
- (C) 2 m
- (D) 3 m

Q148. PHY

A football is kicked with a speed of 20 m/s at an angle of 30° With the horizontal, the maximum height it attains is:

- (A) 5 m
- (B) 10 m
- (C) 15 m
- (D) 20 m

Q149. PHY

A high internal resistance battery is not suitable for heavy loads due to:

- (A) Excess voltage drop
- (B) High terminal voltage
- (C) Infinite emf
- (D) Constant current

Q150. PHY

Two equal charges experience a certain force when placed in vacuum. When the charges are placed in a medium, the force becomes $1/4$ th. The dielectric constant of the medium is:

- (A) 0.25
- (B) 2
- (C) 4
- (D) 16

Q151. PHY

If a test charge of magnitude 2C experience forces of 100N and 200N at two points A and B in an electric field respectively. The ratio of electric fields at A to that of B is:

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

Q152. PHY

A body of mass 2 kg moving with velocity 3 m/s collides with a body of mass 1 kg at rest. If they stick together, their common velocity after collision is:

- (A) 1 m/s
- (B) 2 m/s
- (C) 3 m/s
- (D) 4 m/s

Q153. PHY

Two balls thrown with equal speeds but at different angles cover equal horizontal distance. If one is thrown at an angle of 40° , then the angle of projection of the other is:

- (A) 20°
- (B) 30°
- (C) 45°
- (D) 50°

Q154. PHY

The work done on a body is stored in it in the form of:

- (A) Power
- (B) Energy
- (C) Momentum
- (D) Impulse

Q155. PHY

If 20 waves pass a point in 2 seconds and with a speed of 5m/s, then the wavelength of wave is:

- (A) 0.5 m
- (B) 1 m
- (C) 1.5 m
- (D) 2 m

Q156. PHY

The unit of RC in case of charging a capacitor is:

- (A) Farad
- (B) Seconds
- (C) Ohm
- (D) Volt

Q157. PHY

A longitudinal wave has a frequency of 500 Hz and wavelength of 0.6 m, its speed is:

- (A) 30 m/s
- (B) 83 m/s
- (C) 300 m/s
- (D) 1200 m/s

Q158. PHY

The true statement about angular displacement is:

- (A) It always increases with time
- (B) It is treated as vector for small rotations
- (C) It is always a scalar quantity
- (D) It is measured in meters

Q159. PHY

π radians are equivalent to:

- (A) 30°
- (B) 270°
- (C) 90°
- (D) 180°

Q160. PHY

A person moves 600 m towards north then 300 m towards south. Its displacement to distance ratio is:

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

Q161. PHY

In a stationary wave the point that undergoes zero acceleration is:

- (A) Node
- (B) Antinode
- (C) Midpoint between node and antinode
- (D) Every point along the wave

Q162. PHY

If the speed of sound is measured at sea level and at the top of a mountain, both at the same temperature. It will be:

- (A) Greater at sea level
- (B) Greater at the mountain top
- (C) The same at both places
- (D) Greater where the air is denser

ENG SECTION: ENGLISH

Questions 163 to 171 (9 MCQs)

Q163. ENG

The book was written by Rashid Khan. Identify the correct usage of voice.

- (A) Rashid Khan writes the book.
- (B) Rashid Khan wrote the book.
- (C) Rashid Khan written the book.
- (D) Rashid Khan has write the book.

Q164. ENG

Identify the example of complex sentence.

- (A) I both thanked him and rewarded him.
- (B) Life is what we make it.
- (C) He owed his success to his father.
- (D) Jumping up, he ran away.

Q165. ENG

Pick out the sentence which illustrates the use of infinitive.

- (A) He refused to obey the orders.
- (B) He refused obeying the orders.
- (C) He refused obey the orders.
- (D) He refused obeyed the orders.

Q166. ENG

What is the effect of using different shades of meaning in satire?

- (A) To create a serious tone
- (B) To highlight the absurdity or irony of a situation
- (C) To confuse the reader
- (D) To add complexity to the language

Q167. ENG

People approach the situation differently depending on who they are. The word 'approach' in this sentence means:

- (A) relate
- (B) coordinate
- (C) comprehend
- (D) verify

Q168. ENG

The team won the match, ... they broke the school record.

- (A) Similarly
- (B) Nevertheless
- (C) Furthermore
- (D) Instead

Q169. ENG

Identify the sentence with no spelling errors.

- (A) Rabia completes homework assignments well in time
- (B) Rabia complete homework assignments well in time.
- (C) Rabia completes homework assignments well in time.
- (D) Rabia completes homework assigments well in time.

Q170. ENG

Traveling in hot, dusty terrain gives me no pleasure. The underlined part of the sentence is:

- (A) Adverb phrase
- (B) Prepositional phrase
- (C) Noun phrase
- (D) Infinitive phrase

Q171. ENG

What does "I've told you a million times" means?

- (A) To provide an exact count
- (B) To emphasize frustration or impatience
- (C) To confuse the listener
- (D) To make the character sound foolish

LOGIC SECTION: LOGICAL REASONING

Questions 172 to 180 (9 MCQs)

Q172. LOGIC

An outbreak of a corona disease is reported in the city. What should be the first course of action?

- (A) Develop a vaccination plan.
- (B) Conduct research on the disease.
- (C) Implement quarantine measures.
- (D) Inform the public by using all means.

Q173. LOGIC

Find the next number: 5, 11, 23, 47, 95, ____?

- (A) 190
- (B) 191
- (C) 192
- (D) 193

Q174. LOGIC

Which number comes in the missing place? 1, 3, 7, 15, 31, ____.

- (A) 61
- (B) 63
- (C) 65
- (D) 67

Q175. LOGIC

Every alphabet in the word "SURGEON" represent a fixed numerical value and the numbers when added, sum up to 99. Based on this, what will the sum of the word "EORGNSU".

- (A) 102
- (B) 78
- (C) 99
- (D) 56

Q176. LOGIC

What is the primary difference between hypothesis and a theory?

- (A) hypothesis is a proven fact, while a theory is an unproven data.
- (B) A hypothesis is a specific prediction, while a theory is a broad explanation.
- (C) A hypothesis is a qualitative statement, while a theory is quantitative statement.
- (D) A hypothesis is a tentative explanation, while a theory is a well-established explanation.

Q177. LOGIC

ZX, WU, TR, QO.. What comes next?

- (A) NL
- (B) LN
- (C) NM
- (D) KH

Q178. LOGIC

In a row of students, a student is at 13th position from the left end and at 20th position from the right end. How many students are there in the row?

- (A) 30
- (B) 31
- (C) 32
- (D) 33

Q179. LOGIC

A is older than B but younger than F. C is younger than B but older than D. Who is the youngest of them?

- (A) A
- (B) B
- (C) C
- (D) D

Q180. LOGIC

A hiker climbed to a higher altitude, where he felt the air pressure was lower as compared to the lower altitude. What is the likely effect?

- (A) The hiker felt more energetic.
- (B) The hiker felt no difficulty in breathing.
- (C) The hiker might experience altitude sickness.
- (D) The hiker felt healthier and fresh.

OFFICIAL VERIFIED ANSWER KEY

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

Which of the following hormones in the body of an animal is lipid-based in nature?

CORE CONCEPT & DERIVATION

Hormones are classified chemically into peptides/proteins, amino acid derivatives, and steroids. Steroid hormones are lipid-soluble derivatives of cholesterol synthesized primarily by the adrenal cortex and gonads.

Formula / Rule / Reaction:

Qualitative concept / Steroid hormone classification.

Solution:

- Aldosterone is a mineralocorticoid synthesized from cholesterol by the zona glomerulosa of the adrenal cortex.
- Because of its lipophilic nature, aldosterone readily diffuses across target cell plasma membranes to bind intracellular mineralocorticoid receptors.

Why other options are incorrect:

- **Option A:** Insulin is a globular peptide hormone composed of 51 amino acids organized in two disulfide-linked chains.
- **Option B:** Follicle-stimulating hormone (FSH) is a dimeric glycoprotein gonadotropin secreted by the anterior pituitary gland.
- **Option C:** Oxytocin is a peptide nonapeptide synthesized in the hypothalamus and stored in the posterior pituitary.

Question #2 Key: (C)

BIOLOGY
02. Biomolecules

Which of the following base pairings maintains the constant diameter of the DNA double helix as...

CORE CONCEPT & DERIVATION

The B-DNA double helix maintains a constant uniform diameter of 2.0 nm because each base pair spans the interior of the helix through complementary pairing between a double-ring purine and a single-ring pyrimidine.

Formula / Rule / Reaction:

$$\text{Diameter of B-DNA} \approx 2.0 \text{ nm (20 \AA)}$$

Solution:

- Purines (adenine and guanine) possess a bicyclic planar ring structure measuring approximately 1.2 nm in length.
- Pyrimidines (thymine and cytosine) possess a monocyclic planar ring structure measuring approximately 0.8 nm in length.
- Pairing a purine with a pyrimidine always yields a total distance of 2.0 nm between the two deoxyribose-phosphate backbones across the entire helix axis.

Why other options are incorrect:

- **Option A:** Purine - purine pairs would measure approximately 2.4 nm, producing an outward bulge in the helix.
- **Option B:** Pyrimidine - pyrimidine pairs would measure approximately 1.6 nm, producing an inward collapse of the helix.
- **Option D:** Sugar-phosphate units make up the covalent outer backbone and do not participate in complementary cross-helix base pairs.

Question #3 Key: (B)

BIOLOGY
11. Support & Movement

Which muscle type is under conscious control and is multinucleated?

CORE CONCEPT & DERIVATION

Skeletal muscle tissue consists of elongated, multinucleated cylindrical cells (myofibers) displaying cross-striations that contract voluntarily under the control of the somatic nervous system.

Formula / Rule / Reaction:

Qualitative concept / Muscle tissue histology.

Solution:

- During embryonic development, multiple mononucleated myoblasts fuse end-to-end to form a syncytium, resulting in multinucleated skeletal muscle fibers with peripherally located nuclei.
- Skeletal muscles receive somatic motor innervation, allowing conscious (voluntary) regulation of contraction.

Why other options are incorrect:

- **Option A:** Smooth muscle consists of non-striated, spindle-shaped cells containing a single central nucleus under involuntary autonomic control.
- **Option C:** Cardiac muscle fibers are striated, branched, and typically uninucleated, contracting involuntarily under intrinsic pacemaker and autonomic control.
- **Option D:** Visceral muscle is synonymous with smooth muscle, which is involuntary and mononucleated.

Question #4 Key: (B)

BIOLOGY
11. Support & Movement

Which of the following connective tissues is completely avascular and heals slowly?

CORE CONCEPT & DERIVATION

Cartilage is a specialized supporting connective tissue whose extracellular matrix is completely devoid of internal blood vessels, lymphatics, and nerves, which severely limits its regenerative and repair capacity.

Formula / Rule / Reaction:

Qualitative concept / Connective tissue vascularity.

Solution:

- Chondrocytes reside within isolated lacunae and rely entirely on passive diffusion of nutrients and oxygen through the dense extracellular matrix from blood vessels located in the surrounding perichondrium.
- Because diffusion distances are large and metabolic turnover of chondrocytes is low, damaged cartilage exhibits very poor and slow repair mechanisms.

Why other options are incorrect:

- **Option A:** Bone is a vascularized tissue containing extensive Haversian and Volkmann canals, allowing rapid remodeling and fracture repair.
- **Option C:** Adipose tissue contains an extensive microvascular capillary network essential for lipid storage and mobilization.
- **Option D:** Areolar tissue is loose connective tissue rich in capillaries that support overlying epithelial layers.

Question #5 Key: (D)BIOLOGY
11. Support & Movement

Cardiac muscles are different from skeletal muscles because they:

CORE CONCEPT & DERIVATION

Cardiac muscle shares the sarcomeric arrangement of alternating actin and myosin filaments that produces striations with skeletal muscle, but operates involuntarily under autonomic and myogenic pacemaker control.

Formula / Rule / Reaction:

Qualitative concept / Muscle tissue differentiation.

Solution:

- Both skeletal and cardiac muscle tissues display repeating sarcomeres resulting in microscopic cross-striations.
- While skeletal muscle is innervated by the voluntary somatic motor system, cardiac myocytes are excited by spontaneous pacemaker activity in the sinoatrial node and modulated involuntarily by the autonomic nervous system.

Why other options are incorrect:

- Option A:** Cardiac muscle displays striations; smooth muscle is the muscle type that lacks striations.
- Option B:** Cardiac muscle is involuntary and typically possesses a single centrally located nucleus (occasionally binucleated), not multinucleated.
- Option C:** Cardiac myocytes are typically mononucleated cells joined by intercalated discs, unlike the multinucleated syncytium of skeletal muscle.

Question #6 Key: (D)BIOLOGY
01. Cell

Which organelle gives rise to primary lysosomes through budding in eukaryotic cells?

CORE CONCEPT & DERIVATION

Primary lysosomes are acidic, enzyme-containing storage vesicles that assemble by terminal packaging and budding directly from the trans-Golgi network of Golgi cisternae.

Formula / Rule / Reaction:

Qualitative concept / Endomembrane sorting pathway.

Solution:

- Acid hydrolase enzymes are synthesized by ribosomes bound to the rough endoplasmic reticulum and targeted to the Golgi apparatus via transport vesicles.
- Within the Golgi cisternae, these hydrolytic enzymes undergo mannose-6-phosphate tagging and sorting before budding off from the trans-Golgi cisternae as membrane-bound primary lysosomes.

Why other options are incorrect:

- Option A:** The smooth endoplasmic reticulum specializes in lipid biosynthesis, glycogen metabolism, and calcium sequestration.
- Option B:** The rough endoplasmic reticulum synthesizes the polypeptide chains of lysosomal enzymes but does not bud off mature primary lysosomes.
- Option C:** The plasma membrane forms endocytic vesicles through invagination rather than primary lysosomes.

Question #7 Key: (C)BIOLOGY
02. Biomolecules

A mutation prevents proper disulphide bond formation in a fibrous protein, causing brittle nail...

CORE CONCEPT & DERIVATION

Keratin is an insoluble fibrous structural protein rich in cysteine residues whose covalent disulphide cross-links provide high mechanical rigidity and resistance to hair, nails, and outer epidermal layers.

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

- Alpha-keratin forms the primary structural constituent of nails and hair filaments.
- Extensive covalent disulfide bridges formed between adjacent cysteine side chains hold the protofibrils together; failure to establish these covalent cross-links leads directly to mechanical weakness, manifest as brittle nails and impaired hair growth.

Why other options are incorrect:

- Option A:** Elastin provides elasticity to lungs and large arteries, relying on unique desmosine cross-links rather than extensive disulfide-stabilized keratin fibrils.
- Option B:** Actin is a globular cytoskeletal and contractile protein found in microfilaments.
- Option D:** Collagen is stabilized by hydrogen bonds and covalent cross-links formed by hydroxylysine and hydroxyproline, primarily residing in bone, tendon, and dermis.

Question #8 Key: (B)BIOLOGY
11. Support & Movement

In muscle fibers, T-tubules are extensions of the sarcolemma that penetrate into the cell inter...

CORE CONCEPT & DERIVATION

Transverse (T) tubules are deep tubular invaginations of the muscle sarcolemma that propagate action potentials rapidly from the cell surface into the deep interior of the myofiber.

Formula / Rule / Reaction:

Qualitative concept / Excitation-contraction coupling.

Solution:

- Skeletal muscle fibers have large diameters, meaning surface electrical signals would propagate slowly to interior myofibrils if reliant solely on passive planar conduction.
- T-tubules rapidly transmit sarcolemmal depolarization inward to voltage-gated dihydropyridine (DHP) receptors, opening ryanodine channels in the adjacent sarcoplasmic reticulum terminal cisternae.

Why other options are incorrect:

- Option A:** Actin's binding sites are unblocked when released calcium ions bind troponin C, shifting the tropomyosin complex.
- Option C:** Glycogen synthesis is an enzymatic metabolic process occurring in the sarcoplasm, unrelated to T-tubule electrophysiology.
- Option D:** Calcium ions are sequestered and stored in the terminal cisternae of the sarcoplasmic reticulum, not inside the lumen of T-tubules.

Question #9 Key: (B)BIOLOGY
02. Biomolecules

Polysaccharides such as starch and glycogen are mainly used for:

CORE CONCEPT & DERIVATION

Starch and glycogen are high-molecular-weight polymers of alpha-glucose that serve as non-osmotic, compact storage depots of chemical energy in plants and animals, respectively.

Formula / Rule / Reaction:

Qualitative concept / Storage polysaccharides.

Solution:

- Starch (comprising amylose and amylopectin) acts as the primary long-term carbohydrate reserve in plant tissues.
- Glycogen is a branched alpha-glucan stored in vertebrate liver and skeletal muscle, functioning as an intermediate and short-term reservoir that is mobilized between meals or during muscular exertion.

Why other options are incorrect:

- Option A:** Structural framework roles are performed by beta-linked polysaccharides like cellulose in plants and chitin in fungi/arthropods.
- Option C:** Biological catalysis is carried out by proteinaceous enzymes and ribozymes, not storage carbohydrates.
- Option D:** Free glucose and other monosaccharides act as the immediate ready source of cellular energy.

Question #10 Key: (B)BIOLOGY
02. Biomolecules

In chromosomes, positively charged histone proteins are organized with negatively charged DNA. ...

CORE CONCEPT & DERIVATION

Histone proteins contain high proportions of the basic amino acids lysine and arginine, whose positively charged side chains at physiological pH form electrostatic bonds with the negatively charged phosphate groups of DNA.

Formula / Rule / Reaction:

Lysine side chain: $-(CH_2)_4-NH_3^+$, Arginine side chain: $-(CH_2)_3-NH-C(NH_2)=NH_2^+$

Solution:

- Histones H1, H2A, H2B, H3, and H4 are rich in basic residues (lysine and arginine), carrying net positive charges at physiological pH (pH $\approx$ 7.4).
- These positive charges interact electrostatically with the negatively charged phosphodiester backbone of DNA, enabling tight winding into nucleosome octamers.

Why other options are incorrect:

- Option A:** Alanine has a nonpolar, uncharged aliphatic methyl side chain ($-CH_3$).
- Option C:** Alanine does not carry a positive charge at physiological pH.
- Option D:** Phenylalanine possesses an uncharged, nonpolar aromatic benzyl side chain.

Question #11 Key: (B)BIOLOGY
05. Acellular Life

The envelope in a virus is derived from:

CORE CONCEPT & DERIVATION

The viral envelope is a lipid bilayer acquired by certain animal viruses during maturation when the viral nucleocapsid buds through host cellular membranes.

Formula / Rule / Reaction:

Qualitative concept / Viral envelope biogenesis.

Solution:

- During viral budding, the viral nucleocapsid extrudes through host membranes (such as the plasma membrane, nuclear envelope, or Golgi membranes).
- The resulting envelope consists of host-derived phospholipids and cholesterol, embedded with viral glycoprotein spikes.

Why other options are incorrect:

- Option A:** Host cell ribosomes synthesize polypeptides and do not possess or form lipid bilayer membranes.
- Option C:** Capsid proteins form the internal geometric protein shell enclosing the viral genome, not the outer lipid envelope.
- Option D:** Viral genome replication synthesizes nucleic acid copies, not lipid bilayers.

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

The myelin sheath acts as an:

CORE CONCEPT & DERIVATION

The myelin sheath is a multilayered dielectric lipoprotein wrapping produced around axons that functions as an electrical insulator, preventing ion leakage across the internodal axolemma.

Formula / Rule / Reaction:

Qualitative concept / Neurophysiology of myelin.

Solution:

- Myelin exhibits high electrical resistance and low electrical capacitance due to its high lipid content (approximately 80% lipid).
- This insulation prevents transmembrane ionic dissipation along internodes, restricting depolarization to the unmyelinated nodes of Ranvier and driving rapid saltatory conduction.

Why other options are incorrect:

- Option A:** Although myelin provides secondary physical shielding, its primary neurophysiological role is electrical insulation.
- Option C:** Sensors are specialized sensory receptors or dendrites that transduce stimuli into electrical impulses.
- Option D:** Mechanical support of nervous tissue is provided generally by neuroglial scaffolding and meninges, not the specific physiological role of myelin.

Question #13 Key: (A)BIOLOGY
17. Biotechnology*DNA/RNA probes are most commonly used as:***CORE CONCEPT & DERIVATION**

Nucleic acid probes are defined single-stranded fragments of DNA or RNA labeled with fluorescent, enzymatic, or radioactive markers that detect complementary target sequences through molecular hybridization.

Formula / Rule / Reaction:*Qualitative concept / Molecular hybridization.***Solution:**

- Probes are synthesized complementary to pathogen-specific unique nucleotide sequences.
- When hybridized with clinical patient samples (e.g., in Southern/Northern blots or in situ hybridization), they bind to complementary viral or bacterial genomes, serving as sensitive diagnostic tools for infectious diseases.

Why other options are incorrect:

- Option B:** Vectors such as plasmids, bacteriophages, and cosmids act as carriers in gene cloning.
- Option C:** Polyethylene glycol (PEG) and inactivated Sendai virus serve as fusogenic agents in somatic cell hybridization.
- Option D:** Viral vectors (e.g., retroviruses, adenoviruses) or liposomes act as carriers in gene therapy.

Question #14 Key: (B)BIOLOGY
11. Support & Movement*The event that occurs first during skeletal muscle contraction?***CORE CONCEPT & DERIVATION**

In excitation-contraction coupling, depolarization of the T-tubular membrane must first cause calcium ion efflux from the terminal cisternae before actin active sites are unmasked for myofilament interaction.

Formula / Rule / Reaction:Action Potential → T-tubule depolarization → Ca^{2+} release from SR → Troponin binding → Cross-bridge cycle**Solution:**

- Action potentials invading T-tubules activate DHP receptors, which mechanically open ryanodine receptor channels in the sarcoplasmic reticulum.
- This causes rapid efflux of stored Ca^{2+} into the sarcoplasm, initiating the downstream sequence of troponin binding and cross-bridge formation.

Why other options are incorrect:

- Option A:** Cross-bridge formation cannot occur until calcium binds troponin C to displace tropomyosin from actin.
- Option C:** The power stroke occurs after cross-bridge attachment and the release of inorganic phosphate.
- Option D:** Myosin binds a new ATP molecule at the end of a power stroke to detach from the actin filament.

Question #15 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics*When genes are linked, they tend to:***CORE CONCEPT & DERIVATION**

Gene linkage describes loci situated in proximity on the same chromosome that do not assort independently and tend to be co-transmitted into the same gamete during meiosis.

Formula / Rule / Reaction:*Rule of Genetic Linkage (Morgan).***Solution:**

- Syntenic alleles located closely along the same physical DNA molecule travel together during anaphase I of meiosis.
- Consequently, parental phenotypic combinations appear in the progeny at a frequency greater than the 50% predicted by Mendel's law of independent assortment.

Why other options are incorrect:

- Option A:** Random segregation and independent assortment occur for unlinked genes located on non-homologous chromosomes.
- Option B:** Crossing over between linked genes occurs with a probability proportional to the physical distance separating them, not at every meiotic event.
- Option D:** Separate inheritance is the defining characteristic of unlinked genes.

Question #16 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics*According to Morgan's experiment, which of the following is essential for detecting gene linkage...***CORE CONCEPT & DERIVATION**

Detecting linkage and mapping genetic distances requires large sample sizes to statistically distinguish low-frequency crossover recombinant classes from sampling error.

Formula / Rule / Reaction:

$$\text{Recombination Frequency (\%)} = \frac{\text{Number of Recombinants}}{\text{Total Progeny}} \times 100$$

Solution:

- Recombination through crossing over between closely linked genes produces low numbers of recombinant offspring.
- A large number of progeny is statistically required to reliably calculate the recombination frequency and differentiate true linkage from independent assortment.

Why other options are incorrect:

- Option B:** Small sample sizes introduce severe sampling bias and mask small recombinant classes.
- Option C:** Crossing over does not occur in male *Drosophila melanogaster*; using only males would prevent the observation of recombinant linkage mapping.
- Option D:** Inducing mutations is a tool used to discover new genes, not a requirement to measure linkage between existing alleles.

Question #17 Key: (A)BIOLOGY
11. Support & Movement

The end of skeletal muscle attached with moveable bone is:

CORE CONCEPT & DERIVATION

Skeletal muscles span joints and attach to bones; the attachment site to the bone that is displaced during muscular contraction is termed the insertion.

Formula / Rule / Reaction:

Qualitative concept / Muscle anatomical architecture.

Solution:

- The origin of a muscle is its attachment to the stationary, proximal bone.
- The insertion is its attachment to the moveable, distal bone that is pulled toward the origin when the muscle belly contracts.

Why other options are incorrect:

- **Option B:** The origin anchors the muscle to the relatively fixed or immobile bone.
- **Option C:** A tendon is a cord of dense fibrous connective tissue linking muscle to bone, not the specific functional attachment site.
- **Option D:** The belly is the fleshy, contractile central portion of the muscle.

Question #18 Key: (C)BIOLOGY
13. Chemical Coordination

Which of the following is common between aldosterone, sex hormones and cortisol?

CORE CONCEPT & DERIVATION

Aldosterone, cortisol, and sex steroids share a common chemical classification as steroid hormones derived enzymatically from cholesterol in the adrenal cortex and gonads.

Formula / Rule / Reaction:

Core Structure: Cyclopentanoperhydrophenanthrene ring system (three cyclohexane rings, one cyclopentane ring).

Solution:

- Aldosterone (mineralocorticoid) and cortisol (glucocorticoid) are synthesized in the adrenal cortex, while sex hormones (estrogens, progesterone, androgens) are synthesized in gonads and adrenal tissue.
- All these hormones share the 17-carbon four-ring steroid nucleus derived from cholesterol and are lipophilic signaling molecules that act via intracellular nuclear receptors.

Why other options are incorrect:

- **Option A:** Peptide hormones are polymers of amino acids, such as insulin and parathyroid hormone.
- **Option B:** Phospholipids are structural amphipathic membrane lipids containing glycerol, fatty acids, and a phosphate head.
- **Option D:** Glycoproteins are proteins with covalently attached carbohydrate groups, such as TSH, LH, and FSH.

Question #19 Key: (C)BIOLOGY
10. Homeostasis

Which one of the following organism is uricotelic with reference to secretion of nitrogenous co...

CORE CONCEPT & DERIVATION

Uricotelic animals excrete nitrogenous waste primarily as relatively insoluble uric acid, an adaptation that conserves water in terrestrial and arid environments.

Formula / Rule / Reaction:

Uric acid excretion requires $\approx 1 - 3 \text{ mL H}_2\text{O}$ per gram of nitrogen

Solution:

- Reptiles (including snakes) and birds synthesize uric acid from ammonia to prevent excessive water loss.
- Because uric acid has very low water solubility, it precipitates out of solution and is eliminated as a thick white semi-solid paste through the cloaca.

Why other options are incorrect:

- **Option A:** Humans are ureotelic, eliminating excess nitrogen primarily as water-soluble urea.
- **Option B:** Freshwater fish are ammonotelic, eliminating toxic ammonia directly into the surrounding water through their gills.
- **Option D:** Adult amphibians (frogs) are ureotelic, excreting urea.

Question #20 Key: (B)BIOLOGY
10. Homeostasis

Ureotelism (removal of nitrogenous waste in the form of urea) is an adaptation to the:

CORE CONCEPT & DERIVATION

Ureotelism is an evolutionary adaptation in semi-terrestrial and terrestrial animals that reduces water loss by converting highly toxic ammonia into less toxic, water-soluble urea.

Formula / Rule / Reaction:

Ammonotelism: $\approx 500 \text{ mL H}_2\text{O/g N}$ vs. Ureotelism: $\approx 50 \text{ mL H}_2\text{O/g N}$

Solution:

- Excreting ammonia requires roughly 500 mL of water per gram of nitrogen to prevent toxic cellular injury.
- Terrestrial vertebrates convert ammonia to urea via the ornithine cycle in the liver, which requires only about 50 mL of water per gram of nitrogen, conserving body water under conditions of restricted water availability.

Why other options are incorrect:

- **Option A:** Temperature variations do not determine the metabolic choice of nitrogenous excretion pathway.
- **Option C:** Flooded or open aquatic environments provide abundant water, favoring direct ammonotelism.
- **Option D:** Food shortages alter nitrogen balance but do not determine the biochemical excretion pathway.

Question #21 Key: (D)BIOLOGY
12. Nervous Coordination

All of the following are the characteristics of limbic system EXCEPT:

CORE CONCEPT & DERIVATION

The limbic system is a functional network of forebrain structures regulating emotions, basic drives, and memory consolidation; visual and eye movement reflexes are controlled by brainstem centers.

Formula / Rule / Reaction:

Qualitative concept / Neuroanatomical functional localization.

Solution:

- Reflexive somatic movements of the eyes in response to visual and auditory stimuli are mediated by the superior colliculi of the midbrain and cranial nerve nuclei (III, IV, VI).
- The limbic system (incorporating the amygdala, hippocampus, cingulate gyrus, and hypothalamus) regulates primitive emotions, motivation, and memory.

Why other options are incorrect:

- **Option A:** Primitive emotions (fear, rage, sexual drives) are primary functional outputs of the amygdala and limbic circuits.
- **Option B:** The hippocampus within the limbic system is required for the conversion of short-term memory into long-term memory.
- **Option C:** The hypothalamus, amygdala, and hippocampus are core anatomical components of the limbic system.

Question #22 Key: (B)BIOLOGY
12. Nervous Coordination

Sensory input from auditory and visual pathways, skin and within the body is received by _____.

CORE CONCEPT & DERIVATION

The thalamus serves as the primary sensory relay and processing station of the central nervous system, relaying ascending sensory information (except olfaction) to specific sensory cortices of the cerebrum.

Formula / Rule / Reaction:

Sensory Pathway: Receptors → Second-Order Neurons → Thalamus → Cerebral Cortex.

Solution:

- Ascending sensory inputs from the optic tracts (lateral geniculate nucleus), auditory pathways (medial geniculate nucleus), and somatosensory tracts (ventral posterolateral/posteromedial nuclei) synapse within the thalamus.
- Third-order thalamocortical neurons project these signals to corresponding functional sensory areas of the cerebral cortex for conscious perception and interpretation.

Why other options are incorrect:

- **Option A:** The hypothalamus is an autonomic and endocrine regulatory center, while the cerebellum coordinates motor activities.
- **Option C:** The cerebrum is the ultimate target of sensory projections, not the relay station that receives and redistributes them.
- **Option D:** The cerebellum receives proprioceptive inputs for balance and motor coordination, but does not relay general sensory pathways.

Question #23 Key: (C)BIOLOGY
16. Evolution

According to the Lamarck theory of evolution, the organ that has not been used in several gener...

CORE CONCEPT & DERIVATION

Lamarck's evolutionary principle of use and disuse stated that organs frequently exercised develop and enlarge, whereas unexercised organs undergo progressive reduction, atrophy, and ultimate disappearance over generations.

Formula / Rule / Reaction:

Lamarckian Postulate: Continuous disuse → Vestigialization → Eventual disappearance.

Solution:

- Lamarck proposed that environmental changes create new behavioral needs, leading an organism to cease using certain structures.
- According to this hypothesis, continuous disuse across successive generations causes an organ to progressively shrink and eventually disappear from the species.

Why other options are incorrect:

- **Option A:** An organ becomes strong and enlarged through active, continuous use according to Lamarckism.
- **Option B:** Amputation is surgical or traumatic removal, not an evolutionary mechanism of morphological change.
- **Option D:** Development of an organ is the predicted outcome of repeated use, the exact opposite of disuse.

Question #24 Key: (C)BIOLOGY
03. Enzymes

Which of the following statement is incorrect with reference to the enzyme action?

CORE CONCEPT & DERIVATION

Competitive inhibition is reversible; because the substrate and competitive inhibitor compete for the same active site, sufficiently increasing the substrate concentration outcompetes the inhibitor and restores V_{max} .

Formula / Rule / Reaction:

Competitive Inhibition: $[S] \rightarrow \infty \implies v = V_{max}$

Solution:

- Malonate acts as a classical competitive inhibitor of succinate dehydrogenase due to its close structural resemblance to succinate.
- Adding an excess of succinate increases the probability of succinate binding to the active site over malonate, fully reversing the inhibition; therefore, the statement claiming it does not reverse the inhibition is incorrect.

Why other options are incorrect:

- **Option A:** Substrates specifically bind to the catalytic active site of enzymes to form the enzyme-substrate complex.
- **Option B:** Non-competitive inhibitors bind to allosteric sites separate from the active site, altering the enzyme's catalytic efficiency.
- **Option D:** Malonate is a classic competitive inhibitor of succinate dehydrogenase.

Question #25 Key: (A)BIOLOGY
02. Biomolecules

The temperature of underground water remains constant due to:

CORE CONCEPT & DERIVATION

Water's high specific heat capacity allows it to absorb or release large amounts of heat energy with minimal changes in temperature, providing thermal buffering in subterranean reservoirs.

Formula / Rule / Reaction:

$$q = mc\Delta T \implies \Delta T = \frac{q}{mc}$$

Solution:

- Water has a high specific heat capacity ($c = 4.184 \text{ J/g} \cdot ^\circ\text{C}$) resulting from extensive hydrogen bonding between water molecules.
- Because a large input of thermal energy produces only a small change in temperature (ΔT), underground water insulated from surface atmospheric radiation maintains a stable temperature throughout the year.

Why other options are incorrect:

- **Option B:** Polarity accounts for water's solvent capabilities and hydrogen bonding, but heat capacity is the specific thermodynamic property that stabilizes temperature.
- **Option C:** Heat of vaporization governs the phase change from liquid to gas at the boiling point.
- **Option D:** Specific heat of vaporization relates to phase transitions during evaporation rather than thermal buffering in liquid water.

Question #26 Key: (C)BIOLOGY
05. Acellular Life

The shape of adenovirus is:

CORE CONCEPT & DERIVATION

Adenoviruses are non-enveloped double-stranded DNA viruses with capsids displaying icosahedral symmetry, forming a 20-sided regular polyhedron.

Formula / Rule / Reaction:

Qualitative concept / Viral capsid morphology (20 equilateral triangular faces, 12 vertices).

Solution:

- The adenovirus capsid is a polyhedral structure composed of 252 capsomeres (240 hexons on the triangular faces and 12 pentons at the vertices with radiating fibers).
- This regular polyhedral structure allows the virus to enclose its genome using identical protein subunits.

Why other options are incorrect:

- **Option A:** Helical capsids are rod-shaped cylindrical structures, such as those of Tobacco mosaic virus and Rhabdoviruses.
- **Option B:** Tadpole morphology is characteristic of complex tailed bacteriophages (such as the T-even phages).
- **Option D:** Circular is a two-dimensional geometric term; viral capsids are three-dimensional structures.

Question #27 Key: (C)BIOLOGY
14. Reproduction

In human female normally ovulation occurs at _____ day of menstrual cycle.

CORE CONCEPT & DERIVATION

In a standard 28-day human ovarian cycle, peak estrogen levels trigger a surge of luteinizing hormone (LH), leading to ovulation at approximately day 14.

Formula / Rule / Reaction:

Day of Ovulation = Total Cycle Duration (28 days) – Fixed Luteal Phase (14 days) = Day 14

Solution:

- High levels of estradiol from the mature Graafian follicle trigger an LH surge from the anterior pituitary.
- Approximately 12 to 24 hours after the LH peak (and 14 days after the onset of menses), the mature follicle ruptures, releasing the secondary oocyte into the peritoneal cavity.

Why other options are incorrect:

- **Option A:** Day 9 falls within the proliferative/follicular phase when follicles are still maturing under FSH stimulation.
- **Option B:** Day 11 is too early in a typical 28-day cycle; estrogen levels have not reached the threshold to trigger the LH surge.
- **Option D:** Day 15 corresponds to the early secretory/luteal phase following ovulation.

Question #28 Key: (C)BIOLOGY
05. Acellular Life

HIV belongs to which class of virus with respect to genome type?

CORE CONCEPT & DERIVATION

Human Immunodeficiency Virus (HIV) is a retrovirus (Baltimore Group VI) carrying two identical single-stranded positive-sense RNA molecules that serve as templates for reverse transcription into complementary DNA.

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

- HIV is an enveloped lentivirus containing two copies of positive-sense ssRNA.
- Upon infection, its virally encoded reverse transcriptase uses the ssRNA genome as a template to synthesize double-stranded viral DNA, which then integrates into the host chromosome.

Why other options are incorrect:

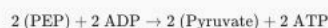
- **Option A:** Single-stranded DNA genomes are characteristic of Parvoviruses (Baltimore Group II).
- **Option B:** Double-stranded RNA genomes are characteristic of Reoviruses and Rotaviruses (Baltimore Group III).
- **Option D:** ssRNA acting directly as a template for mRNA synthesis describes negative-sense ssRNA viruses (Baltimore Group V, like Influenza and Rhabdoviruses).

Question #29 Key: (B)BIOLOGY
04. Bioenergetics

How many ATPs are produced during oxidative phase of glycolysis?

CORE CONCEPT & DERIVATION

The pay-off (oxidative) phase of glycolysis generates four ATP molecules per glucose molecule via substrate-level phosphorylation, yielding a net gain of two ATP after accounting for the two ATP invested in the preparatory phase.

Formula / Rule / Reaction:

$$\text{Total ATP produced in pay-off phase} = 2 + 2 = 4 \text{ ATP}$$

Solution:

- Glycolysis is divided into an energy-investment phase (which consumes 2 ATP) and an energy-yielding/oxidative phase.
- In the oxidative phase, two triose phosphate molecules undergo substrate-level phosphorylation at the phosphoglycerate kinase step (producing 2 ATP) and at the pyruvate kinase step (producing 2 ATP).
- The total number of ATP molecules synthesized during this phase is 4 ATP (yielding a net of $4 - 2 = 2$ ATP for the overall pathway).

Why other options are incorrect:

- Option A:** 2 is the net ATP yield of the overall glycolytic pathway after subtracting the 2 ATP invested in the preparatory phase.
- Option C:** 34 represents the theoretical ATP yield generated across the complete respiratory chain via oxidative phosphorylation.
- Option D:** 36 is the classical total theoretical net yield of ATP per glucose molecule from complete aerobic respiration.

Question #30 Key: (B)BIOLOGY
01. Cell

Which of the following best describes the relationship between endoplasmic reticulum (ER) and G...

CORE CONCEPT & DERIVATION

The endoplasmic reticulum acts as the biosynthetic and structural precursor to the Golgi apparatus within the secretory pathway, supplying proteins, lipids, and membrane vesicles to the cis-Golgi network.

Formula / Rule / Reaction:

Biosynthetic-Secretory Pathway: RER / SER $\rightarrow$ COPII Transport Vesicles $\rightarrow$ cis-Golgi $\rightarrow$ trans-Golgi.

Solution:

- Polypeptides, glycoproteins, and lipids synthesized in the ER are packaged into COPII-coated transport vesicles.
- These vesicles travel to and fuse with the cis face of the Golgi cisternae, establishing the ER as the upstream precursor in membrane and material transport.

Why other options are incorrect:

- Option A:** The ER and Golgi apparatus interact continuously through anterograde and retrograde vesicular transport.
- Option C:** The Golgi receives material from the ER; it does not serve as a precursor to the ER.
- Option D:** The ER focuses on primary protein synthesis, initial folding, and lipid synthesis, whereas the Golgi specializes in oligosaccharide remodeling, sorting, and packaging.

Question #31 Key: (A)BIOLOGY
10. Homeostasis

Osmotic gradient of inner medulla of kidney is increased by:

CORE CONCEPT & DERIVATION

The hyperosmotic medullary gradient required for urinary concentration is established by sodium chloride reabsorption in the loop of Henle and the medullary recycling of urea from the collecting ducts.

Formula / Rule / Reaction:

$$\text{Total Medullary Osmolality} \approx [\text{NaCl}] + [\text{Urea}] \approx 1200 - 1400 \text{ mOsm/L}$$

Solution:

- In the presence of antidiuretic hormone (ADH), the inner medullary collecting duct becomes permeable to urea via UT-A1 and UT-A3 transporters.
- Urea diffuses into the medullary interstitium, contributing nearly half of the inner medullary osmotic gradient (up to 500 to 600 mOsm/L) to drive water reabsorption.

Why other options are incorrect:

- Option B:** Water reabsorption into the interstitium dilutes the solute concentration, dissipating the gradient if not drained by the vasa recta.
- Option C:** Phosphate is primarily reabsorbed in the proximal tubule and functions as a urinary buffer rather than a medullary osmolyte.
- Option D:** Interstitial potassium is maintained at low levels to prevent abnormal disruption of membrane potentials.

Question #32 Key: (B)BIOLOGY
14. Reproduction

Decreased level of FSH hormone during menstrual cycle triggers release of:

CORE CONCEPT & DERIVATION

During the late follicular phase, rising estrogen and inhibin from the dominant follicle depress FSH secretion through negative feedback, while sustained high estrogen levels switch to positive feedback on the pituitary to trigger the LH surge.

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

- As the dominant follicle matures, it secretes high levels of estradiol, which lowers FSH release via negative feedback on the anterior pituitary.
- When circulating estradiol remains elevated above threshold for over 36 hours, it triggers a positive feedback surge of luteinizing hormone (LH), inducing ovulation.

Why other options are incorrect:

- Option A:** Human chorionic gonadotropin (hCG) is secreted by syncytiotrophoblasts of the blastocyst following implantation.
- Option C:** Oxytocin is released from the posterior pituitary in response to uterine contraction during labor and suckling during lactation.
- Option D:** Progesterone is secreted by the corpus luteum after the LH surge induces ovulation.

Question #33 Key: (A)BIOLOGY
08. Immunity

The digestive secretions from different parts of GIT have the ability to kill microbes present in...

CORE CONCEPT & DERIVATION

Antimicrobial agents are classified by their site of application; agents that destroy or inhibit microorganisms on living tissues or internal mucosal surfaces act as antiseptics.

Formula / Rule / Reaction:

Qualitative concept / Antimicrobial classification.

Solution:

- Antiseptics are substances that prevent infection by destroying or inhibiting microorganisms on or within living tissues without causing tissue toxicity.
- Gastrointestinal secretions (including gastric hydrochloric acid and salivary lysozyme) kill ingested microorganisms along mucosal surfaces, functioning endogenously as natural antiseptics.

Why other options are incorrect:

- Option B:** Disinfectants are chemical agents applied to non-living, inanimate objects and are too toxic for living tissues.
- Option C:** Chemotherapeutics are synthetic or biosynthesized drugs administered systemically to treat internal infections or cancers.
- Option D:** Immunosuppressants dampen immune responses, increasing susceptibility to microbial infection.

Question #34 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

A carrier female for hemophilia can pass the defective allele to:

CORE CONCEPT & DERIVATION

Hemophilia is an X-linked recessive disorder; a heterozygous carrier female has one mutant X chromosome (X^h) that she passes to 50% of her offspring regardless of sex.

Formula / Rule / Reaction:

Mother: $X^H X^h \xrightarrow{\text{Meiosis}} 50\% \text{ Gametes with } X^H, 50\% \text{ Gametes with } X^h$

Solution:

- A carrier mother possesses the genotype $X^H X^h$.
- During gametogenesis, her two X chromosomes segregate independently into ova.
- She contributes the X^h allele to 50% of her male offspring (who express hemophilia, $X^h Y$) and 50% of her female offspring (who become carriers, $X^H X^h$), meaning the defective allele can be inherited by both sons and daughters.

Why other options are incorrect:

- Option A:** Daughters also receive one X chromosome from their mother and can inherit the X^h allele to become carriers.
- Option B:** Sons receive an X chromosome from their mother and can inherit the defective allele.
- Option D:** A carrier mother produces gametes carrying the mutant allele in half of her ovulations.

Question #35 Key: (A)BIOLOGY
07. Circulation / Transport

During ventricular systole, which pressure changes occur?

CORE CONCEPT & DERIVATION

During ventricular systole, isovolumetric contraction increases intraventricular pressure above atrial pressure (closing the AV valves), and subsequent ejection raises it above arterial outflow pressure (opening the semilunar valves).

Formula / Rule / Reaction:

Ventricular Systole: $P_{\text{ventricle}} > P_{\text{atrium}}$ and $P_{\text{ventricle}} > P_{\text{artery}}$

Solution:

- When the ventricles contract, intraventricular pressure rises rapidly above atrial pressure, snapping the atrioventricular (mitral and tricuspid) valves shut.
- As contraction continues, ventricular pressure exceeds the diastolic pressure in the aorta ($> 80 \text{ mmHg}$) and pulmonary trunk ($> 10 \text{ mmHg}$), opening the semilunar valves to eject blood.

Why other options are incorrect:

- Option B:** Atrial pressure exceeds ventricular pressure during ventricular diastole, driving ventricular filling.
- Option C:** If ventricular pressure fell below arterial pressure, the semilunar valves would close and ejection would stop.
- Option D:** Ventricular pressure falling below atrial pressure occurs during diastole, not systole.

Question #36 Key: (C)BIOLOGY
08. Immunity

Which cell type is essential for stimulating cell division of both B-cells and T-cells?

CORE CONCEPT & DERIVATION

Helper T-lymphocytes ($CD4^+$) coordinate adaptive immunity by secreting cytokines that stimulate the proliferation and differentiation of both B-lymphocytes and cytotoxic T-lymphocytes.

Formula / Rule / Reaction:

Activated $CD4^+$ T-cell $\xrightarrow{IL-2, IL-4, IL-5}$ Clonal expansion of B-cells and T-cells

Solution:

- Upon antigen recognition on MHC Class II molecules, helper T-cells secrete interleukin-2 (IL-2).
- IL-2 acts as an autocrine and paracrine growth factor that stimulates clonal division of both cytotoxic T-cells ($CD8^+$) and B-cells, driving adaptive immune responses.

Why other options are incorrect:

- Option A:** Plasma cells are terminally differentiated B-cells that produce antibodies and do not stimulate lymphocyte division.
- Option B:** Memory cells persist to mediate accelerated secondary immune responses and do not direct primary lymphocyte proliferation.
- Option D:** Neutrophils are innate phagocytic granulocytes that do not direct lymphocyte cell division.

Question #37 Key: (C)BIOLOGY
10. Homeostasis

The hormone, when overproduced can lead to hypercalcemia and stone formation is

CORE CONCEPT & DERIVATION

Parathyroid hormone (PTH) raises serum calcium by stimulating osteoclast-mediated bone resorption, renal tubular calcium reabsorption, and vitamin D activation; its overproduction produces hypercalcemia and nephrolithiasis.

Formula / Rule / Reaction:

$\uparrow \text{PTH} \rightarrow \uparrow \text{Bone Resorption} + \uparrow \text{Renal Ca}^{2+} \text{ Reabsorption} \rightarrow \text{Hypercalcemia} \rightarrow \text{Calcium Kidney Stones}$

Solution:

- Excessive PTH secretion (hyperparathyroidism) mobilizes large amounts of calcium from bone into the bloodstream.
- The filtered load of calcium exceeds the renal reabsorption capacity, leading to hypercalciuria; this excess urinary calcium precipitates as calcium oxalate or calcium phosphate kidney stones.

Why other options are incorrect:

- Option A:** Insulin regulates blood glucose levels and does not directly control calcium homeostasis.
- Option B:** Thyroxine controls basal metabolic rate; excess levels do not typically cause primary hypercalcemia with kidney stones.
- Option D:** Calcitonin lowers blood calcium by inhibiting osteoclasts, counteracting hypercalcemia and stone formation.

Question #38 Key: (C)BIOLOGY
11. Support & Movement

Fibrocartilage is found in:

CORE CONCEPT & DERIVATION

Fibrocartilage contains dense, orderly bundles of type I collagen fibers that provide tensile strength and shock absorption in weight-bearing joints.

Formula / Rule / Reaction:

Qualitative concept / Cartilage histological distribution.

Solution:

- Fibrocartilage forms the menisci of the knee joint, the pubic symphysis, and the intervertebral discs.
- In the knee joint, the fibrocartilaginous menisci act as shock absorbers that disperse compressive stresses during movement.

Why other options are incorrect:

- Option A:** The trachea is supported by C-shaped rings of hyaline cartilage.
- Option B:** The structural framework of the external nose is made of hyaline cartilage.
- Option D:** Ear flaps (auricles) are composed of flexible elastic cartilage.

Question #39 Key: (C)BIOLOGY
10. Homeostasis

Additional capillaries present in the juxtamedullary nephrons to form a loop of vessels are:

CORE CONCEPT & DERIVATION

Juxtamedullary nephrons possess long, hairpin-shaped capillary loops called the vasa recta that parallel the loops of Henle into the renal medulla to function as countercurrent exchangers.

Formula / Rule / Reaction:

Qualitative concept / Renal microvasculature.

Solution:

- Efferent arterioles of juxtamedullary nephrons descend deep into the renal medulla to form hairpin loops called the vasa recta.
- These capillary loops remove reabsorbed water and solutes while maintaining the medullary hyperosmotic gradient through passive countercurrent exchange.

Why other options are incorrect:

- Option A:** Efferent arterioles carry blood out of the glomerulus and supply the capillary networks.
- Option B:** Peritubular capillaries form an interconnected mesh surrounding the proximal and distal convoluted tubules in the renal cortex.
- Option D:** Afferent arterioles deliver blood directly into the glomerular capillaries for filtration.

Question #40 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

Y-linked inheritance refers to which mode of the inheritance?

CORE CONCEPT & DERIVATION

Y-linked (holandric) inheritance describes the direct transmission of genes located on the non-homologous region of the Y chromosome exclusively from father to son.

Formula / Rule / Reaction:

Holandric Transmission: Father (XY^*) $\rightarrow$ 100% Sons (XY^*) (0% Daughters)

Solution:

- Because the Y chromosome is present only in males, Y-linked traits pass along the direct male lineage across generations.
- This transmission is termed 'straight' (patrilineal) inheritance, contrasting with the crisscross pattern typical of X-linked recessive traits.

Why other options are incorrect:

- Option A:** Crisscross inheritance describes X-linked recessive traits passing from affected fathers to carrier daughters, then to grandsons.
- Option C:** 'Loop' is not a recognized genetic inheritance pattern.
- Option D:** 'Jumping' refers to transposable genetic elements, not chromosomal inheritance patterns.

Question #41 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

If a colorblind lady marries a normal man, their children will be:

CORE CONCEPT & DERIVATION

Red-green color blindness is an X-linked recessive trait; males inherit their single X chromosome from their mother, while daughters receive an X chromosome from each parent.

Formula / Rule / Reaction:

Cross: X^cX^c (Colorblind Mother) $\times$ X^CY (Normal Father)

Progeny: 100% Sons X^cY (Colorblind), 100% Daughters X^CX^c (Carriers)

Solution:

- The colorblind mother contributes a recessive X^c allele to every child.
- Sons receive the father's Y chromosome and the mother's X^c , making all sons colorblind (X^cY).
- Daughters receive the father's dominant normal allele (X^C) and the mother's X^c , making all daughters phenotypically normal carriers (X^CX^c).

Why other options are incorrect:

- **Option A:** All sons are colorblind because they receive their only X chromosome from the affected mother.
- **Option B:** Sons cannot be normal because the mother contributes only the mutant X^c allele.
- **Option D:** Daughters are carriers rather than colorblind because they inherit a normal dominant X^C allele from the father.

Question #42 Key: (B)BIOLOGY
07. Circulation / Transport

All of the following properties of water are associated with its capillary action. EXCEPT:

CORE CONCEPT & DERIVATION

Capillary action is the spontaneous movement of water through narrow spaces driven by adhesive forces, cohesive intermolecular forces, and surface tension.

Formula / Rule / Reaction:

$$h = \frac{2\gamma \cos \theta}{\rho g r}$$

Solution:

- Adhesion between polar water molecules and hydrophilic surfaces, combined with cohesive hydrogen bonding between water molecules, generates surface tension that pulls the liquid column upward.
- Although fluid density (ρ) determines the downward gravitational force acting on the column, it is not a driving force of capillary action.

Why other options are incorrect:

- **Option A:** Adhesion provides the electrostatic attraction between water and tube surfaces that drives liquid ascent.
- **Option C:** Cohesion maintains the continuous column of water molecules via intermolecular hydrogen bonding.
- **Option D:** Surface tension acts at the meniscus to pull the water column upward against gravity.

Question #43 Key: (A)BIOLOGY
01. Cell

Which organelle serves as a packaging and a distribution center for molecules within the cells?

CORE CONCEPT & DERIVATION

The Golgi apparatus chemically modifies, sorts, and packages proteins and lipids received from the endoplasmic reticulum into secretory or transport vesicles.

Formula / Rule / Reaction:

Qualitative concept / Endomembrane transport.

Solution:

- Transport vesicles from the endoplasmic reticulum fuse with the cis-Golgi network.
- Within the Golgi cisternae, enzymes modify proteins and lipids, sorting and packaging them into transport vesicles at the trans face for delivery to lysosomes, the plasma membrane, or for secretion.

Why other options are incorrect:

- **Option B:** Mitochondria generate cellular ATP via the Krebs cycle and oxidative phosphorylation.
- **Option C:** Ribosomes are ribonucleoprotein complexes responsible for translating mRNA into polypeptides.
- **Option D:** Vacuoles serve primarily for storage, turgor maintenance, and waste isolation.

Question #44 Key: (A)BIOLOGY
14. Reproduction

Which of the following hormone is not produced in older women?

CORE CONCEPT & DERIVATION

Menopause involves the depletion of ovarian follicles, resulting in the cessation of ovarian estrogen biosynthesis in older women.

Formula / Rule / Reaction:

Qualitative concept / Postmenopausal endocrinology.

Solution:

- During reproductive years, the ovaries synthesize the vast majority of circulating estrogen (17-beta-estradiol).
- With menopause and follicular depletion, the ovaries cease estrogen production, causing a marked drop in systemic estrogen levels.

Why other options are incorrect:

- **Option B:** Gastrin is secreted by gastric G-cells to stimulate gastric acid production, independent of age.
- **Option C:** Secretin is released by duodenal S-cells to stimulate pancreatic secretion, unaffected by menopause.
- **Option D:** Renin is produced by the juxtaglomerular cells of the kidney to regulate blood pressure throughout life.

Question #45 Key: (B)BIOLOGY
07. Circulation / Transport*Which lymphatic structure absorbs dietary fats in the intestine?***CORE CONCEPT & DERIVATION**

Lacteals are specialized, blunt-ended lymphatic capillaries located within intestinal villi that absorb long-chain dietary fats packaged as chylomicrons.

Formula / Rule / Reaction:

Dietary Lipids → Chylomicrons → Central Lacteals → Thoracic Duct → Venous Circulation

Solution:

- Long-chain fatty acids absorbed by enterocytes are assembled into chylomicrons, which are too large to pass through continuous blood capillaries.
- The central lacteals of the intestinal villi possess wide endothelial fenestrations and discontinuous basal laminae that allow chylomicrons to enter lymphatic drainage.

Why other options are incorrect:

- Option A:** Peyer's patches are aggregates of lymphoid tissue in the ileum that mediate gut mucosal immunity.
- Option C:** The pancreatic duct conveys digestive enzymes and bicarbonate from the pancreas to the duodenum.
- Option D:** Lymph nodes filter lymph and house lymphocytes, but do not directly absorb lipids from the intestinal lumen.

Question #46 Key: (A)BIOLOGY
12. Nervous Coordination*Thinking, memory and voluntary actions are mainly controlled by the:***CORE CONCEPT & DERIVATION**

The cerebrum, particularly the cerebral cortex, is the primary control center for higher intellectual functions, conscious thought, reasoning, memory integration, and the initiation of voluntary motor activity.

Formula / Rule / Reaction:

Qualitative concept / Functional neuroanatomy.

Solution:

- The cerebral hemispheres contain functional sensory, motor, and association areas responsible for perception, voluntary commands, speech, and intellect.
- While subcortical structures assist in memory processing, overall voluntary command and higher cognitive processes are directed by the cerebrum.

Why other options are incorrect:

- Option B:** The cerebellum coordinates muscular movements, posture, and balance, but does not initiate voluntary thought.
- Option C:** The pons acts as a bridge connecting brain regions and houses pneumotaxic centers for respiratory rhythmicity.
- Option D:** The hippocampus specializes in consolidating short-term memory into long-term memory, but does not govern voluntary actions or general thinking.

Question #47 Key: (D)BIOLOGY
07. Circulation / Transport*Ventricular diastole causes:***CORE CONCEPT & DERIVATION**

Ventricular diastole is the relaxation phase of the ventricular myocardium during which intraventricular pressure drops below arterial pressure, causing the semilunar valves to snap shut.

Formula / Rule / Reaction:

Ventricular Diastole: $P_{\text{ventricle}} < P_{\text{artery}} \implies$ Backflow closes aortic and pulmonary semilunar

Solution:

- As the ventricles relax, intraventricular pressure drops below the pressures in the aorta and pulmonary trunk.
- Elastic recoil of the great arteries forces blood back toward the ventricles, catching the valve cusps and causing closure of the semilunar valves to prevent regurgitation.

Why other options are incorrect:

- Option A:** Ventricular contraction defines ventricular systole, not diastole.
- Option B:** Closure of atrioventricular (mitral and tricuspid) valves occurs at the onset of ventricular systole.
- Option C:** Semilunar valves open during the ejection phase of ventricular systole when ventricular pressure exceeds arterial pressure.

Question #48 Key: (D)BIOLOGY
01. Cell*Which of the following statements correctly describes the organelle that is not membrane bound?***CORE CONCEPT & DERIVATION**

Ribosomes are non-membrane-bound cellular organelles composed of ribosomal ribonucleic acid (rRNA) and structural proteins that carry out protein translation.

Formula / Rule / Reaction:

Eukaryotic Ribosome (80S) = Small Subunit (40S) + Large Subunit (60S)

Solution:

- Ribosomes lack a surrounding phospholipid bilayer membrane.
- Each ribosome consists of two ribonucleoprotein subunits assembled from rRNA molecules and specific ribosomal polypeptides.

Why other options are incorrect:

- Option A:** Cristae are inner membrane folds characteristic of mitochondria, which are double-membrane-bound organelles.
- Option B:** Modification and packaging of proteins is the function of the Golgi apparatus, a membrane-bound organelle.
- Option C:** Digestive hydrolytic enzymes are enclosed within lysosomes, which are single-membrane-bound vesicles.

Question #49 Key: (C)BIOLOGY
17. Biotechnology

A biological laboratory is developing gene therapy with a modified virus that infects birds onl...

CORE CONCEPT & DERIVATION

Viruses are classified based on host tropism; viruses that specifically infect vertebrate and invertebrate animal hosts, including avian species (class Aves), are designated animal viruses.

Formula / Rule / Reaction:

Qualitative concept / Viral host taxonomy.

Solution:

- Birds are members of the kingdom Animalia (phylum Chordata).
- A virus that infects avian host cells is classified as an animal virus.

Why other options are incorrect:

- **Option A:** Algal viruses specifically infect photosynthetic eukaryotic algae.
- **Option B:** Fungal viruses (mycoviruses) specifically infect fungal organisms.
- **Option D:** Bacterial viruses (bacteriophages) infect bacterial prokaryotes.

Question #50 Key: (B)BIOLOGY
10. Homeostasis

CFTR gene that encodes a protein which regulates:

CORE CONCEPT & DERIVATION

The Cystic Fibrosis Transmembrane Conductance Regulator (CFTR) gene encodes an ABC transporter-class chloride ion channel that regulates salt and water balance across epithelial surfaces.

Formula / Rule / Reaction:

Active Cl^- transport $\rightarrow$ Passive Na^+ flux $\rightarrow$ Osmotic H_2O movement

Solution:

- CFTR regulates the secretion of chloride ions and the secondary reabsorption of sodium ions across mucosal membranes.
- Osmotic gradients generated by this salt transport drive the movement of water, maintaining proper hydration of mucus in the respiratory, digestive, and reproductive tracts.

Why other options are incorrect:

- **Option A:** CFTR does not transport or regulate whole proteins across membranes.
- **Option C:** CFTR does not govern glucose or carbohydrate homeostasis.
- **Option D:** This option is an inaccurate and ambiguous description of electrolyte transport.

Question #51 Key: (A)BIOLOGY
01. Cell

Which organelle is usually referred as post office of the cell and why?

CORE CONCEPT & DERIVATION

The Golgi complex functions as the intracellular post office by receiving newly synthesized molecules from the endoplasmic reticulum, modifying them, attaching molecular destination tags, and packaging them into transport vesicles.

Formula / Rule / Reaction:

Qualitative concept / Endomembrane transport.

Solution:

- Proteins and lipids arrive at the cis-Golgi network from the endoplasmic reticulum.
- Within the cisternae, they undergo glycosylation and phosphorylation, which serve as molecular address labels, before sorting and packaging at the trans face for delivery to lysosomes, the cell membrane, or secretory pathways.

Why other options are incorrect:

- **Option B:** The rough endoplasmic reticulum serves as the site of translation for secretory and membrane proteins, not the sorting post office.
- **Option C:** Mitochondria are the powerhouses of the cell that generate ATP.
- **Option D:** The nucleus contains genetic material and serves as the cellular control center.

Question #52 Key: (C)BIOLOGY
12. Nervous Coordination

Components of reflex arc must contain neurons from:

CORE CONCEPT & DERIVATION

A reflex arc is the neural pathway that mediates a reflex action; minimally, it requires a sensory pathway to detect the stimulus and a motor pathway to stimulate the effector.

Formula / Rule / Reaction:

Reflex Arc: Receptor $\rightarrow$ Sensory Neuron $\rightarrow$ [Interneuron in CNS] $\rightarrow$ Motor Neuron $\rightarrow$ Effector

Solution:

- Every functional reflex arc must contain an afferent (sensory) neuron to transmit impulses to the central nervous system and an efferent (motor) neuron to convey response impulses to muscles or glands.
- Monosynaptic reflexes (such as the patellar stretch reflex) require only sensory and motor neurons, making them the essential components of the circuit.

Why other options are incorrect:

- **Option A:** A mixed nerve is a composite anatomical trunk containing both sensory and motor axons, not a distinct functional class of neuron.
- **Option B:** Monosynaptic reflex arcs function without intermediate neurons (interneurons).
- **Option D:** This option lacks sensory neurons, which are required to detect the initial stimulus.

Question #53 Key: (B)BIOLOGY
08. Immunity

A confirmed COVID patient shows weak specific immunity. Which component is most likely deficient...

CORE CONCEPT & DERIVATION

Specific (adaptive) immunity requires CD4⁺ helper T-lymphocytes to recognize viral antigens and release cytokines that activate B-cells for humoral immunity and cytotoxic T-cells for cell-mediated immunity.

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

- Helper T-lymphocytes coordinate adaptive immune responses against SARS-CoV-2.
- A deficiency or depletion of helper T-lymphocytes impairs both antibody production by B-cells and cytotoxic T-cell-mediated elimination of virally infected host cells.

Why other options are incorrect:

- **Option A:** Red blood cells function in oxygen and carbon dioxide gas transport and do not direct specific immunity.
- **Option C:** Thrombocytes (platelets) are cell fragments involved in hemostasis and blood clotting.
- **Option D:** Suppressor (regulatory) T-lymphocytes downregulate immune activity; their deficiency causes autoimmunity rather than weak specific immunity.

Question #54 Key: (B)BIOLOGY
08. Immunity

Which of the following organ takes part in the T-cell maturation for both the lymphatic and end...

CORE CONCEPT & DERIVATION

The thymus is a primary lymphoid organ that provides the microenvironment for T-lymphocyte maturation and acts as an endocrine gland by secreting peptide hormones like thymosin.

Formula / Rule / Reaction:

Qualitative concept / Dual lymphatic-endocrine physiology.

Solution:

- Immature pro-T cells migrate from the bone marrow to the thymus, where they undergo positive and negative selection to mature into immunocompetent T-lymphocytes.
- Thymic epithelial cells also synthesize and release hormones, such as thymosin and thymopoietin, qualifying the thymus as an endocrine gland.

Why other options are incorrect:

- **Option A:** The spleen is a secondary lymphoid organ that filters blood, but does not support T-cell maturation or function as an endocrine gland.
- **Option C:** The liver is a metabolic organ and exocrine/endocrine gland, but does not mature T-lymphocytes.
- **Option D:** The kidney secretes erythropoietin and renin, but has no role in T-cell maturation.

Question #55 Key: (B)BIOLOGY
14. Reproduction

The part of male reproductive system that maintains the temperature for sperm production is:

CORE CONCEPT & DERIVATION

Spermatogenesis requires an optimal temperature approximately $2 - 3^{\circ}\text{C}$ below core body temperature, which is maintained by the external suspension and muscular activity of the scrotum.

Formula / Rule / Reaction:

$$T_{\text{scrotal}} \approx 34 - 35^{\circ}\text{C} \quad \text{Core body temperature} \approx 37^{\circ}\text{C}$$

Solution:

- The scrotum is an extra-abdominal pouch that houses the testes outside the warmer pelvic cavity.
- Contraction and relaxation of the dartos and cremaster muscles adjust the distance of the testes from the body wall in response to ambient temperature changes.

Why other options are incorrect:

- **Option A:** The testes are the gonads that produce spermatozoa and testosterone; they do not regulate their own external temperature.
- **Option C:** The vas deferens is the muscular duct that transports mature spermatozoa from the epididymis to the ejaculatory duct.
- **Option D:** The epididymis is the coiled tubular structure where spermatozoa mature and gain motility.

Question #56 Key: (C)BIOLOGY
08. Immunity

After Liver transplant, doctors suppress the T-lymphocyte activity in patient. Why?

CORE CONCEPT & DERIVATION

Acute allograft rejection is mediated by host T-lymphocytes that recognize foreign human leukocyte antigens (MHC molecules) on the donor organ, initiating cytotoxic destruction of the graft.

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

- Recipient CD4⁺ and CD8⁺ T-cells recognize foreign major histocompatibility complex (MHC) proteins on the donor liver tissue.
- Immunosuppressive drugs (such as cyclosporine or tacrolimus) inhibit T-cell activation and cytokine release, preventing immune-mediated graft rejection.

Why other options are incorrect:

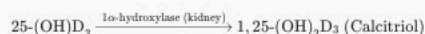
- **Option A:** Suppressing T-lymphocyte activity decreases helper T-cell signals, thereby reducing antibody production.
- **Option B:** Suppressing T-cells impairs immune defenses, increasing vulnerability to opportunistic infections.
- **Option D:** Immunosuppression inhibits the formation and proliferation of memory cells.

Question #57 Key: (B)BIOLOGY
10. Homeostasis

How do the kidneys contribute to maintain normal blood calcium level?

CORE CONCEPT & DERIVATION

The kidneys regulate extracellular calcium levels by modulating tubular calcium reabsorption and performing the final hydroxylation of vitamin D into active calcitriol.

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

- Under the influence of parathyroid hormone (PTH), renal tubular epithelial cells increase active calcium reabsorption in the thick ascending limb and distal convoluted tubule.
- Kidney enzymes convert calcidiol into active calcitriol (1,25-dihydroxycholecalciferol), which stimulates intestinal absorption of dietary calcium.

Why other options are incorrect:

- Option A:** Kidneys do not serve as storage reservoirs for calcium; bones store calcium.
- Option C:** Kidneys filter and reabsorb calcium rather than synthesizing and secreting it de novo into the blood.
- Option D:** Calcium is a chemical element that cannot be converted into organic urea molecules.

Question #58 Key: (B)BIOLOGY
12. Nervous Coordination

Nodes of Ranvier along the length of axon fibers allow:

CORE CONCEPT & DERIVATION

Nodes of Ranvier are unmyelinated gaps along a myelinated axon where high concentrations of voltage-gated sodium channels allow action potentials to jump from node to node via saltatory conduction.

Formula / Rule / Reaction:

$$v_{\text{saltatory}} \gg v_{\text{continuous}} \quad (\text{Conduction velocity increases up to } 100 - 120 \text{ m/s})$$

Solution:

- The insulating myelin sheath prevents ion leakage along the internodes.
- Inward sodium currents generated during an action potential travel electrotonically along the axon to depolarize the next node of Ranvier, allowing rapid saltatory propagation.

Why other options are incorrect:

- Option A:** Neurotransmitter diffusion occurs exclusively across synaptic clefts at axon terminals, not along the axon shaft.
- Option C:** Synaptogenesis occurs at axonal growth cones and dendritic spines, not along internodal shafts.
- Option D:** Neurogenesis occurs in neurogenic niches of the central nervous system, unrelated to axonal nodes.

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

Arachidonic acid, which is the precursor molecule for prostaglandins is:

CORE CONCEPT & DERIVATION

Arachidonic acid is a 20-carbon polyunsaturated omega-6 fatty acid with four cis double bonds, serving as the direct biosynthetic precursor for prostaglandins, thromboxanes, and leukotrienes.

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

- Arachidonic acid possesses a 20-carbon carboxylic acid chain containing four carbon-carbon double bonds (tetra-unsaturated).
- Cyclooxygenase enzymes (COX-1 and COX-2) convert liberated arachidonic acid into prostaglandin H_2 (PGH_2), which is converted into active prostaglandins.

Why other options are incorrect:

- Option A:** Saturated 18-carbon fatty acid refers to stearic acid.
- Option B:** Unsaturated 18-carbon fatty acids include oleic, linoleic, and alpha-linolenic acids, not arachidonic acid.
- Option C:** Arachidonic acid has four double bonds, not three.

Question #60 Key: (C)BIOLOGY
07. Circulation / Transport

Atrial walls are thinner as compared to ventricles because:

CORE CONCEPT & DERIVATION

The thickness of a cardiac chamber myocardium corresponds to the workload and resistance it encounters; atria pump against low resistance into adjacent ventricles, requiring less muscle mass.

Formula / Rule / Reaction:

$$\text{Myocardial Wall Tension} \propto \text{Pressure} \times \text{Radius}$$

Solution:

- The atria receive venous blood and pump it across low-resistance atrioventricular valves into the ventricles immediately below them.
- Because this requires minimal pressure, atrial walls possess a thin layer of pectinate muscle, whereas ventricles must generate high pressure to overcome systemic and pulmonary vascular resistance.

Why other options are incorrect:

- Option A:** Chamber volume does not dictate wall thickness; stroke volume in atria and ventricles is balanced.
- Option B:** Anatomical position above the ventricles does not explain the physiological requirement for thin walls.
- Option D:** Blood enters the atria via bulk flow driven by venous hydrostatic pressure gradients, not osmosis.

Question #61 Key: (A)BIOLOGY
17. Biotechnology

A patient with a genetic disorder undergoes treatment where a normal gene is inserted into thei...

CORE CONCEPT & DERIVATION

Gene therapy is a therapeutic technique that delivers functional copies of a gene into patient cells to correct, replace, or compensate for a defective or missing pathogenic allele.

Formula / Rule / Reaction:

Qualitative concept / Recombinant biotechnology.

Solution:

- In gene therapy, viral vectors or non-viral delivery systems introduce functional therapeutic genes into target cells.
- Expression of the inserted gene produces functional proteins, alleviating the symptoms of the genetic disorder.

Why other options are incorrect:

- **Option B:** Genetic testing involves analyzing DNA to identify mutations, not treating disorders.
- **Option C:** Protein engineering alters protein sequences and structures for industrial or pharmaceutical use.
- **Option D:** DNA fingerprinting identifies individuals using variable tandem repeats (VNTRs/STRs) for forensic analysis.

Question #62 Key: (A)BIOLOGY
10. Homeostasis

Which of the following is not a potential symptom of chronic renal failure?

CORE CONCEPT & DERIVATION

Chronic renal failure causes uremic syndrome, manifesting as bone disorders, neurological symptoms, and electrolyte abnormalities; nephritis and bacterial infections represent causes rather than resulting symptoms.

Formula / Rule / Reaction:

Etiology vs. Clinical Manifestation in Renal Pathophysiology.

Solution:

- Chronic renal failure leads to secondary hyperparathyroidism causing bone pain/fractures, uremic encephalopathy causing confusion, and hypocalcemia/hyperkalemia causing muscle cramps.
- Nephritis and pyelonephritis are inflammatory diseases that can cause renal failure, but are not direct symptoms produced by the failing kidney.

Why other options are incorrect:

- **Option B:** Renal osteodystrophy caused by deficient calcitriol synthesis leads directly to bone demineralization, pain, and pathological fractures.
- **Option C:** Accumulation of uremic neurotoxins causes uremic encephalopathy, characterized by impaired concentration and confusion.
- **Option D:** Electrolyte disturbances, such as hypocalcemia and hyperphosphatemia, produce muscle cramps and tetany.

Question #63 Key: (C)BIOLOGY
11. Support & Movement

Arthritis is a disease that primarily affects the:

CORE CONCEPT & DERIVATION

Arthritis is a musculoskeletal disorder characterized by acute or chronic inflammation, erosion, and degenerative changes within articular cartilage and synovial joints.

Formula / Rule / Reaction:

Qualitative concept / Pathology of the skeletal system.

Solution:

- Arthritis encompasses joint disorders such as osteoarthritis (degeneration of articular cartilage) and rheumatoid arthritis (autoimmune destruction of synovial membranes).
- The primary pathological manifestations are joint pain, swelling, stiffness, and reduced range of motion.

Why other options are incorrect:

- **Option A:** Inflammatory diseases of the kidneys are classified as nephritis or nephrosis.
- **Option B:** Inflammatory diseases of the lungs include pneumonia, bronchitis, and pneumonitis.
- **Option D:** Muscle inflammation is termed myositis.

Question #64 Key: (A)BIOLOGY
12. Nervous Coordination

Osmoreceptors that detect the osmotic pressure of blood are primarily located in the:

CORE CONCEPT & DERIVATION

Central osmoreceptors located in specialized circumventricular organs of the hypothalamus monitor plasma osmolality and coordinate water balance by regulating thirst and antidiuretic hormone (ADH) secretion.

Formula / Rule / Reaction:

↑ Plasma Osmolality (> 295 mOsm/kg) → Hypothalamic Osmoreceptor Shrinkage → ↑ ADH

Solution:

- Osmoreceptive neurons reside in the anterior hypothalamus (including the organum vasculosum of the lamina terminalis and supraoptic nuclei).
- When blood osmotic pressure increases, these cells lose water via osmosis, shrink, and trigger neural signals that stimulate thirst and ADH release from the posterior pituitary.

Why other options are incorrect:

- **Option B:** The cerebellum integrates vestibular and proprioceptive inputs to coordinate voluntary motor function and balance.
- **Option C:** The medulla oblongata houses autonomic centers controlling heart rate, vasomotor tone, and respiration.
- **Option D:** The cerebral cortex handles conscious sensory processing and reasoning, but does not house primary homeostatic osmoreceptors.

Question #65 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

A chromosome which contains the centromere at the center is called:

CORE CONCEPT & DERIVATION

Chromosomes are categorized morphologically by centromere location; a metacentric chromosome features a centrally placed centromere that divides the chromosome into two arms of equal length.

Formula / Rule / Reaction:

$$\text{Arm Ratio } (r = q/p) \approx 1.0 \implies \text{Metacentric (V-shaped during anaphase)}$$

Solution:

- In a metacentric chromosome, the primary constriction (centromere) is positioned at the midpoint.
- This produces equal-length p and q arms, giving the chromosome a characteristic V-shape during anaphase movement toward spindle poles.

Why other options are incorrect:

- Option A:** Mesocentric is not a recognized cytogenetic classification term.
- Option C:** Acrocentric chromosomes have the centromere positioned near one end, producing one very short arm (p) and one long arm (q).
- Option D:** Telocentric chromosomes have the centromere located at the terminal end, leaving only a single arm.

Question #66 Key: (C)BIOLOGY
03. Enzymes

Binding site for a substrate on enzyme is:

CORE CONCEPT & DERIVATION

The active site is the specific three-dimensional cleft on an enzyme where substrate molecules bind and undergo catalytic conversion into products.

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

- The active site consists of a substrate-binding site that provides chemical specificity and a catalytic site with amino acid side chains that lower activation energy.
- Substrates bind to this site via non-covalent interactions (hydrogen bonds, ionic interactions, van der Waals forces).

Why other options are incorrect:

- Option A:** Allosteric sites are secondary binding sites separate from the active site that bind non-substrate regulatory molecules.
- Option B:** Passive site is not a recognized biochemical term in enzymology.
- Option D:** Regulatory sites bind activators or inhibitors to modulate enzyme conformation, rather than binding the primary reaction substrate.

Question #67 Key: (D)BIOLOGY
02. Biomolecules

The most abundant polysaccharide in plants, widely used in paper and as a source of dietary fib...

CORE CONCEPT & DERIVATION

Cellulose is a linear, unbranched homopolysaccharide of beta-D-glucose residues joined by beta-1,4-glycosidic bonds, forming the structural basis of plant cell walls and human dietary fiber.

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

- Cellulose accounts for over 50% of all organic carbon in the plant kingdom, serving as the main structural material in plant cell walls and the raw material for paper production.
- Because humans lack the cellulase enzyme required to hydrolyze beta-1,4-glycosidic bonds, cellulose passes undigested through the gastrointestinal tract, functioning as dietary fiber.

Why other options are incorrect:

- Option A:** Chitin is a structural polysaccharide composed of N-acetylglucosamine found in fungal cell walls and arthropod exoskeletons.
- Option B:** Glycogen is the branched storage polysaccharide of animals, not plants.
- Option C:** Starch consists of alpha-glucose polymers (amylose and amylopectin) that are easily digested by human amylase, functioning as a nutrient source rather than dietary fiber.

Question #68 Key: (C)BIOLOGY
01. Cell

This given organelle is involved in the synthesis of oil, phospholipids and steroids:

CORE CONCEPT & DERIVATION

The smooth endoplasmic reticulum (SER) contains membrane-bound enzymes that synthesize neutral lipids, fatty acids, phospholipids, and steroid hormones.

Formula / Rule / Reaction:

Qualitative concept / Lipid metabolic pathways in endomembranes.

Solution:

- The smooth endoplasmic reticulum lacks ribosomes and specializes in lipid metabolism.
- It contains key enzymes that assemble phospholipids for cellular membranes and convert cholesterol into steroid hormones in endocrine tissues.

Why other options are incorrect:

- Option A:** Mitochondria generate ATP via oxidative phosphorylation and the Krebs cycle.
- Option B:** The Golgi complex modifies, sorts, and packages macromolecules received from the ER, but does not carry out de novo lipid biosynthesis.
- Option D:** Ribosomes translate messenger RNA into polypeptide chains and have no role in lipid synthesis.

Question #69 **Key: (A)**BIOLOGY
12. Nervous Coordination*Which type of neurons stimulate the muscles to contract in a reflex arc?***CORE CONCEPT & DERIVATION**

Efferent (motor) neurons convey motor impulses away from the central nervous system to peripheral effector organs, such as skeletal muscle fibers, triggering contraction.

Formula / Rule / Reaction:

CNS Integration $\xrightarrow{\text{Action potential in efferent axon}}$ Neuromuscular Junction $\rightarrow$ Muscle Contraction

Solution:

- In a reflex arc, sensory information processed in the spinal cord triggers action potentials in efferent (motor) neurons.
- The efferent axons exit via the ventral roots and release acetylcholine at neuromuscular junctions, stimulating muscle contraction.

Why other options are incorrect:

- **Option B:** Sensory neurons carry impulses from peripheral sensory receptors toward the central nervous system.
- **Option C:** Interneurons are local circuit neurons within the CNS that integrate information between sensory and motor pathways.
- **Option D:** Afferent neurons is another term for sensory neurons, which carry signals into the central nervous system.

Question #70 **Key: (D)**BIOLOGY
12. Nervous Coordination*Receptors that are located in the retina of eye are called:***CORE CONCEPT & DERIVATION**

Rod and cone cells are specialized neuroepithelial photoreceptors in the neural retina that transduce light photons into graded electrical potentials.

Formula / Rule / Reaction:

Photon Absorption by Rhodopsin/Photopsin $\rightarrow$ 11-cis to all-trans retinal $\rightarrow$ Hyperpolarization

Solution:

- The retina contains two classes of photoreceptor cells: rods and cones.
- Rods contain rhodopsin and mediate dim-light (scotopic) monochromatic vision, while cones contain photopsins and mediate bright-light (photopic) high-acuity color vision.

Why other options are incorrect:

- **Option A:** Merkel discs are slow-adapting mechanoreceptors located in the basal epidermis that detect light touch.
- **Option B:** Ruffini endings are slow-adapting mechanoreceptors in the dermis that detect skin stretch.
- **Option C:** Pacinian corpuscles are rapidly adapting mechanoreceptors in subcutaneous tissue that detect deep pressure and high-frequency vibration.

Question #71 **Key: (C)**BIOLOGY
06. Digestion/Nutrition*The bony roof of the oral cavity, which separates it from the nasal cavity, is formed by the:***CORE CONCEPT & DERIVATION**

The hard palate forms the rigid anterior bony septum separating the oral cavity from the nasal cavity, composed of the palatine processes of the maxillae and the horizontal plates of the palatine bones.

Formula / Rule / Reaction:

Hard Palate = Palatine Processes of Maxillae (anterior 2/3) + Horizontal Plates of Palatine Bones

Solution:

- The superior surface of the hard palate forms the floor of the nasal cavity, while its inferior surface forms the bony roof of the oral cavity.
- This rigid plate provides a solid counter-surface for the tongue during mastication and deglutition.

Why other options are incorrect:

- **Option A:** The soft palate is a posterior, flexible fibromuscular partition that lacks a bony internal framework.
- **Option B:** The mandible forms the lower jaw and the skeletal framework of the floor of the mouth.
- **Option D:** While the maxilla contributes its palatine processes to the hard palate, the anatomical structure separating the cavities is the hard palate itself, which also includes the palatine bones.

Question #72 **Key: (C)**BIOLOGY
12. Nervous Coordination*Which structure in neuron is responsible for receiving information from other neurons?***CORE CONCEPT & DERIVATION**

Dendrites are branching cytoplasmic extensions of the neuron that receive synaptic inputs from other neurons and convey incoming graded potentials toward the soma.

Formula / Rule / Reaction:

Information Flow in Neurons: Dendrites (reception) $\rightarrow$ Soma (integration) $\rightarrow$ Axon (conduction) $\rightarrow$ Terminal (transmission).

Solution:

- Dendritic branches possess dendritic spines equipped with ligand-gated ion channels and neurotransmitter receptors.
- Neurotransmitters released from presynaptic neurons bind these receptors, generating postsynaptic potentials that propagate toward the cell body.

Why other options are incorrect:

- **Option A:** The axon conducts action potentials away from the soma toward target effectors.
- **Option B:** The soma houses the nucleus and organelles, integrating electrical potentials rather than serving as the primary receptive arbor.
- **Option D:** Axon terminals release neurotransmitters into the synaptic cleft to transmit signals to downstream cells.

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

Chemicals that stimulate the olfactory receptors enter the nasal cavity in the form of

CORE CONCEPT & DERIVATION

Olfactory chemoreceptors detect volatile airborne chemical compounds that enter the respiratory tract in the gaseous phase before dissolving in the mucosal layer of the olfactory epithelium.

Formula / Rule / Reaction:

Qualitative concept / Olfactory sensory transduction.

Solution:

- Inhaled odorant molecules must be sufficiently volatile to travel as airborne gases into the superior nasal cavity.
- Upon reaching the olfactory epithelium, these gaseous molecules dissolve into the surface mucus layer and bind to G-protein coupled odorant receptors on olfactory cilia.

Why other options are incorrect:

- Option A:** Particulate solids cannot diffuse through the inhaled airstream to reach olfactory receptors.
- Option B:** While odorants dissolve in mucus on mucosal surfaces, they enter the nasal cavity as airborne vapors/gases.
- Option D:** Plasma is an ionized gas state found at high temperatures, not compatible with physiological respiration.

Question #74 Key: (D)BIOLOGY
13. Chemical Coordination

Neurosecretory cells are:

CORE CONCEPT & DERIVATION

Neurosecretory cells are specialized neurons that translate neural signals into chemical endocrine signals by releasing neurohormones directly into the bloodstream from their axon terminals.

Formula / Rule / Reaction:

Neural Action Potential → Axon Terminal Depolarization → Neurohormone Exocytosis into Capillaries.

Solution:

- Neurosecretory cells (such as magnocellular neurons of the paraventricular and supraoptic hypothalamic nuclei) possess dendrites, a soma, and an axon.
- Instead of innervating another neuron or muscle at a synapse, their axon terminals terminate on capillary walls to release hormones (e.g., ADH and oxytocin) into circulation.

Why other options are incorrect:

- Option A:** Typical endocrine cells are non-neuronal epithelial cells that synthesize and release hormones.
- Option B:** Exocrine cells discharge secretions through ducts onto epithelial surfaces, not into the bloodstream.
- Option C:** Neuroglial cells provide metabolic and structural support in the nervous system and do not conduct impulses or secrete systemic neurohormones.

Question #75 Key: (C)BIOLOGY
16. Evolution

Lamarck theory of evolution was rejected experimentally by:

CORE CONCEPT & DERIVATION

August Weismann experimentally refuted Lamarck's hypothesis of the inheritance of acquired characteristics by demonstrating that somatic mutilations are not transmitted to offspring, establishing the Germ Plasm Theory.

Formula / Rule / Reaction:

Germ Plasm Theory: Somatoplasm changes $\nrightarrow$ Germplasm (Heritable information)

Solution:

- Weismann cut off the tails of laboratory mice across 22 consecutive generations.
- In every generation, newborn mice developed tails of normal length, proving that acquired somatic changes do not modify the germline DNA inherited by offspring.

Why other options are incorrect:

- Option A:** Ernst Haeckel formulated the biogenetic law ('ontogeny recapitulates phylogeny') and supported evolutionary theory.
- Option B:** Charles Darwin proposed natural selection as the mechanism of evolution, but did not experimentally disprove Lamarck.
- Option D:** Thomas R. Malthus wrote an essay on population growth that influenced Darwin and Wallace, but did not conduct biological experiments on Lamarckism.

Question #76 Key: (A)BIOLOGY
02. Biomolecules

Which of the following characteristics is common among sucrose, lactose and maltose?

CORE CONCEPT & DERIVATION

Sucrose, lactose, and maltose are structural isomers belonging to the class of hexose disaccharides, all formed from two hexose units via condensation and sharing the same molecular formula.

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

- Maltose (glucose + glucose), lactose (glucose + galactose), and sucrose (glucose + fructose) each contain 12 carbon, 22 hydrogen, and 11 oxygen atoms.
- All three disaccharides share the identical molecular formula $C_{12}H_{22}O_{11}$.

Why other options are incorrect:

- Option B:** Occurrence in living beings is a generic property of many biomolecules and does not uniquely define or unite these sugars.
- Option C:** Their monosaccharide compositions differ: maltose contains two glucoses, lactose contains glucose and galactose, and sucrose contains glucose and fructose.
- Option D:** Maltose and lactose are reducing sugars with free anomeric carbons, but sucrose is a non-reducing sugar because both anomeric carbons are tied up in the glycosidic bond.

Question #77 Key: (B)BIOLOGY
02. Biomolecules

Ribozymes are the only biocatalysts that are made up of:

CORE CONCEPT & DERIVATION

Ribozymes are catalytically active ribonucleic acid (RNA) molecules capable of accelerating specific chemical reactions in the absence of proteinaceous enzymes.

Formula / Rule / Reaction:

Catalytic RNA (e.g., 23S rRNA in peptidyl transferase) → Peptide bond synthesis

Solution:

- Discovered by Thomas Cech and Sidney Altman, ribozymes fold into defined tertiary structures using intramolecular base pairing.
- Examples include self-splicing group I/II introns, the RNA subunit of RNase P, and the peptidyl transferase center of ribosomal 23S/28S rRNA.

Why other options are incorrect:

- Option A:** DNA serves primarily as genetic storage and does not act as a natural biological catalyst in vivo.
- Option C:** Conventional enzymes are composed of polypeptides (proteins), which ribozymes are contrasted against.
- Option D:** Fatty acids are structural lipid units that do not possess intrinsic biocatalytic activity.

Question #78 Key: (B)BIOLOGY
03. Enzymes

The induced fit model differs from the Lock and Key model because the enzyme in this model:

CORE CONCEPT & DERIVATION

Daniel Koshland's induced fit model proposes that the enzyme active site is structurally flexible, undergoing a conformational change upon substrate binding to optimize catalytic interactions.

Formula / Rule / Reaction:

Enzyme (relaxed conformation) + Substrate → Enzyme-Substrate Complex (induced complementary conformation)

Solution:

- Unlike Emil Fischer's rigid Lock and Key model, the induced fit model posits that the active site is not a static template.
- Substrate binding induces precise conformational changes in the enzyme active site, aligning catalytic residues to stabilize the transition state and lower the activation energy.

Why other options are incorrect:

- Option A:** A rigid, fixed active site describes the Lock and Key hypothesis.
- Option C:** Enzymes operating by induced fit maintain substrate specificity based on complementary chemical interactions.
- Option D:** Enzyme denaturation involves irreversible loss of tertiary structure, which does not occur during normal catalysis.

Question #79 Key: (D)BIOLOGY
03. Enzymes

Which competitive inhibitor blocks the enzyme responsible for bacterial cell wall synthesis?

CORE CONCEPT & DERIVATION

Penicillin contains a beta-lactam ring that structurally mimics the D-alanyl-D-alanine terminus of bacterial peptidoglycan precursors, competitively and irreversibly inhibiting transpeptidase.

Formula / Rule / Reaction:

Penicillin + Transpeptidase (PBP) → Inactivated Covalent Penicilloyl-Enzyme Complex

Solution:

- Bacterial cell wall synthesis requires transpeptidase enzymes to cross-link glycan chains with peptide bridges.
- Penicillin fits into the transpeptidase active site as a structural analogue, blocking cross-link formation and causing osmotic lysis of dividing bacteria.

Why other options are incorrect:

- Option A:** Sulfonamides competitively inhibit dihydropteroate synthase to block bacterial folic acid synthesis.
- Option B:** Streptomycin is an aminoglycoside that binds the 30S ribosomal subunit to inhibit protein synthesis.
- Option C:** Tetracycline blocks the binding of aminoacyl-tRNA to the A-site of the 30S ribosomal subunit.

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

Water commonly known as a universal solvent because:

CORE CONCEPT & DERIVATION

Water's bent geometry and electronegativity difference create a strong molecular dipole, allowing it to dissolve ionic compounds via hydration shells and polar substances via hydrogen bonding.

Formula / Rule / Reaction:

$$\text{Dielectric constant of water } (\epsilon_r \approx 80) \implies F = \frac{1}{4\pi\epsilon_r\epsilon_0} \frac{q_1q_2}{r^2} \ll F_{\text{vacuum}}$$

Solution:

- Water molecules possess a permanent electrical dipole with a partial negative charge on oxygen and partial positive charges on hydrogen.
- Water readily forms hydration shells around cations and anions, attenuating electrostatic attractions and dissolving a wide range of ionic and polar substances.

Why other options are incorrect:

- Option B:** Water frequently acts as a direct chemical reactant in hydrolysis and condensation reactions.
- Option C:** High specific heat capacity provides thermal buffering, but does not explain solvent capacity.
- Option D:** Solvation depends on polarity and dielectric properties, not simply small molecular volume.

Question #81 Key: (B)

BIOLOGY
02. Biomolecules

Which of the following structural change in water molecule leads to the low density of ice?

CORE CONCEPT & DERIVATION

When water freezes, each molecule forms four hydrogen bonds arranged in a rigid, open hexagonal crystal lattice, causing the structure to expand and reducing its density relative to liquid water.

Formula / Rule / Reaction:

$$\rho_{\text{ice}} (0^\circ\text{C}) \approx 0.917 \text{ g/cm}^3 < \rho_{\text{water}} (4^\circ\text{C}) \approx 1.000 \text{ g/cm}^3$$

Solution:

- In liquid water, hydrogen bonds continuously break and reform, allowing molecules to pack closely together with maximum density at 4°C .
- Upon freezing at 0°C , water molecules are fixed into an open tetrahedral lattice held by four hydrogen bonds, increasing the total volume by roughly 9% and lowering the density of ice.

Why other options are incorrect:

- Option A:** Water molecules do not form ionic bonds; bonding in ice remains covalent with intermolecular hydrogen bonding.
- Option C:** Kinetic energy decreases as liquid water cools and transitions into solid ice.
- Option D:** Water molecules retain their polar dipole structure in the solid phase.

Question #82 Key: (A)

CHEMISTRY
18. Carboxylic Acids

Reduction of carboxylic acid by using lithium aluminumhydride produce

CORE CONCEPT & DERIVATION

Lithium aluminium hydride (LiAlH_4) is a strong reducing agent that reduces carboxylic acids to primary alcohols through nucleophilic acyl substitution followed by hydride addition.

Formula / Rule / Reaction:



Solution:

- Carboxylic acids are reduced by LiAlH_4 via transfer of hydride ions (H^-) to the carbonyl carbon.
- The carboxylic acid is converted to an aldehyde intermediate, which undergoes immediate reduction to yield a primary alcohol as the final product.

Why other options are incorrect:

- Option B:** Acid halides are produced by reacting carboxylic acids with thionyl chloride (SOCl_2) or phosphorus halides ($\text{PCl}_3, \text{PCl}_5$).
- Option C:** Esters are synthesized via Fischer esterification of carboxylic acids with alcohols in the presence of an acid catalyst.
- Option D:** Reducing carboxylic acids directly to alkanes requires harsh conditions, such as red phosphorus with HI.

Question #83 Key: (B)

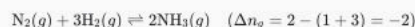
CHEMISTRY
07. Equilibrium

In separate vessel of volume 2000 cm^3 and 1500 cm^3 , 6g of hydrogen and 28g of nitrogen are mixed...

CORE CONCEPT & DERIVATION

According to Le Chatelier's principle, increasing the pressure of a gaseous equilibrium system by decreasing the container volume shifts the equilibrium toward the side with fewer gas moles.

Formula / Rule / Reaction:



Solution:

- The forward synthesis of ammonia results in a decrease in gas moles from 4 moles of reactants to 2 moles of product.
- The 1500 cm^3 vessel has a smaller volume than the 2000 cm^3 (2 L) vessel, generating a higher total pressure for the same initial mole quantities.
- This higher pressure shifts the equilibrium toward the product side, producing a higher yield of ammonia in the 1500 cm^3 vessel.

Why other options are incorrect:

- Option A:** The 2 L vessel has a larger volume and lower equilibrium pressure, shifting the reaction toward reactants.
- Option C:** The yield is not equal because equilibrium position depends on system volume when $\Delta n_g \neq 0$.
- Option D:** The direction of the shift is predicted by Le Chatelier's principle.

Question #84 Key: (C)

CHEMISTRY
05. Liquids

The weakest intermolecular force present in liquid is?

CORE CONCEPT & DERIVATION

Instantaneous dipole-induced dipole forces (London dispersion forces) arise from temporary, transient fluctuations in electron density and represent the weakest class of intermolecular interactions.

Formula / Rule / Reaction:

Relative Strength: London Dispersion < Dipole-Dipole < Hydrogen Bonding << Covalent/Ionic

Solution:

- Temporary displacement of the electron cloud in a nonpolar or polar molecule creates a momentary instantaneous dipole.
- This temporary dipole induces a complementary dipole in an adjacent molecule, resulting in weak attractive forces that quickly dissipate.

Why other options are incorrect:

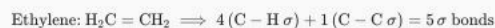
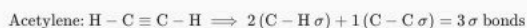
- Option A:** Dipole-dipole forces involve electrostatic attractions between permanent molecular dipoles, which are stronger than dispersion forces.
- Option B:** Permanent dipole-induced dipole forces (Debye forces) are stronger than instantaneous dispersion interactions.
- Option D:** Hydrogen bonding is a strong type of dipole-dipole attraction occurring between hydrogen and electronegative atoms (N, O, F).

Question #85 Key: (A)CHEMISTRY
03. Chemical Bonding

Number of sigma bond in acetylene and ethylene are?

CORE CONCEPT & DERIVATION

A single covalent bond is a sigma bond; a double bond consists of one sigma and one pi bond; a triple bond consists of one sigma and two pi bonds.

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

- In acetylene (ethyne, C_2H_2), the two C-H bonds are single sigma bonds and the central carbon-carbon triple bond contains one sigma and two pi bonds, totaling 3 sigma bonds.
- In ethylene (ethene, C_2H_4), the four C-H bonds are single sigma bonds and the carbon-carbon double bond contains one sigma and one pi bond, totaling 5 sigma bonds.

Why other options are incorrect:

- Option B:** Ethylene possesses 5 sigma bonds, not 3.
- Option C:** Acetylene contains 3 sigma bonds, not 6.
- Option D:** Reverses the order and miscounts sigma bonds in both hydrocarbons.

Question #86 Key: (C)CHEMISTRY
03. Chemical Bonding

Which of the following has smallest bond angle?

CORE CONCEPT & DERIVATIONBond angles are determined by electron pair geometry and central atom hybridization; according to Drago's rule, hydrides of group 16 elements below oxygen utilize nearly pure p-orbitals, producing bond angles close to 90° .**Formula / Rule / Reaction:****Solution:**

- Acetylene (C_2H_2) and beryllium chloride (BeCl_2) are linear molecules with sp hybridization and 180° bond angles.
- Ammonia (NH_3) exhibits sp^3 hybridization with one lone pair, yielding a trigonal pyramidal angle of 107.5° .
- Hydrogen sulfide (H_2S) involves a large sulfur atom with low electronegativity where bonding utilizes almost pure 3p orbitals, yielding an angle of approximately 92.1° , the smallest among the choices.

Why other options are incorrect:

- Option A:** Acetylene has a linear bond angle of 180° .
- Option B:** Ammonia has a bond angle of 107.5° , which is larger than that of H_2S .
- Option D:** Beryllium chloride has a linear bond angle of 180° .

Question #87 Key: (D)CHEMISTRY
03. Chemical Bonding

Which one of the following has highest ionic character?

CORE CONCEPT & DERIVATIONThe percentage of ionic character in a chemical bond is directly proportional to the difference in electronegativity ($\Delta\chi$) between the bonded atoms, with values exceeding 1.7 typically denoting predominantly ionic bonds.**Formula / Rule / Reaction:****Solution:**

- Sodium hydride (NaH) is an ionic crystalline salt containing discrete Na^+ cations and H^- hydride anions with high melting and boiling points.
- By contrast, BCl_3 and PCl_3 are covalent molecular gases and liquids, while AlCl_3 forms a covalent dimer (Al_2Cl_6) that readily sublimates, exhibiting strong covalent behavior due to the high charge density of Al^{3+} .

Why other options are incorrect:

- Option A:** AlCl_3 possesses significant covalent character due to polarization of chloride electron clouds by Al^{3+} (Fajans rules).
- Option B:** BCl_3 is a trigonal planar non-polar covalent molecule.
- Option C:** PCl_3 is a covalent molecular compound with polar covalent P-Cl bonds.

Question #88 Key: (A)CHEMISTRY
03. Chemical Bonding

Which one has highest bond energy?

CORE CONCEPT & DERIVATION

Covalent bond energy increases with greater s-character of the overlapping hybrid orbital, because higher s-character brings the bonding electrons closer to the nucleus, yielding shorter and stronger bonds.

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

- An sp hybrid orbital contains 50% s-character, making it smaller and more compact than sp^2 (33.3%) or sp^3 (25%) orbitals.
- When an sp orbital overlaps with an s-orbital, it achieves effective orbital overlap and a shorter internuclear distance, resulting in the highest bond dissociation energy.

Why other options are incorrect:

- Option B:** An sp^3 -s bond has only 25% s-character, resulting in a longer, weaker bond.
- Option C:** An sp^2 -s bond contains 33.3% s-character, which produces a weaker bond than sp-s.
- Option D:** An sp^3 -p bond involves directional p-orbitals with low s-character, producing a longer bond with lower dissociation energy.

Question #89 Key: (B)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

The relationship of (+) tartaric acid and (-) Tartaric acid are:

CORE CONCEPT & DERIVATION

Enantiomers are stereoisomers that are non-superimposable mirror images of each other, possessing identical physical properties except for the direction in which they rotate plane-polarized light.

Formula / Rule / Reaction:

Specific Rotation: $[\alpha]_D$ of (+) Tartaric acid = $-[\alpha]_D$ of (-) Tartaric acid

Solution:

- Tartaric acid possesses two chiral stereocenters (2R,3R and 2S,3S).
- The dextrorotatory (+) isomer and levorotatory (-) isomer represent non-superimposable mirror images that rotate plane-polarized light in equal and opposite directions, defining them as enantiomers.

Why other options are incorrect:

- Option A:** Geometric isomers (cis/trans) require restricted rotation, typically around double bonds or ring systems.
- Option C:** Diastereomers are stereoisomers that are not mirror images of one another (such as meso-tartaric acid compared to (+) tartaric acid).
- Option D:** Tartaric acid features tetrahedral sp^3 chiral carbons and is a non-planar three-dimensional molecule.

Question #90 Key: (B)

CHEMISTRY
17. Aldehydes & KetonesThe IUPAC name of compound $C_6H_5COCH_3$ is:

CORE CONCEPT & DERIVATION

Under IUPAC rules for aliphatic-aromatic ketones, the open carbon chain containing the principal carbonyl group serves as the parent alkane chain, with the aromatic ring designated as a substituent.

Formula / Rule / Reaction:

$C_6H_5 - C(=O) - CH_3 \Rightarrow$ Parent: Ethane ($C_1 - C_2$) $\rightarrow$ Ethanone; Substituent at C_1 : Phenyl

Solution:

- The ketone carbonyl is part of a two-carbon aliphatic chain, establishing the parent stem as ethanone.
- The phenyl group ($-C_6H_5$) is attached to carbon-1 of this chain, giving the systematic IUPAC name 1-phenylethan-1-one (phenylethanone).

Why other options are incorrect:

- Option A:** Methyl phenyl ketone is the traditional common (radicofunctional) name, not the systematic IUPAC name.
- Option C:** Octan-2-one is an unbranched eight-carbon aliphatic ketone.
- Option D:** Benzylethanone implies an extra methylene unit ($-CH_2 - C_6H_5$), representing 1-phenylpropan-2-one rather than acetophenone.

Question #91 Key: (C)

CHEMISTRY
17. Aldehydes & Ketones

During reaction of aldehyde with HCN, the hybridization of carbon atom of carbonyl group change...

CORE CONCEPT & DERIVATION

Nucleophilic addition of hydrogen cyanide to a carbonyl group transforms the trigonal planar carbonyl carbon into a tetrahedral cyanohydrin carbon, altering its hybridization from sp^2 to sp^3 .

Formula / Rule / Reaction:



Solution:

- In the parent aldehyde, the carbonyl carbon forms three sigma bonds and one pi bond, adopting trigonal planar geometry with sp^2 hybridization.
- Attack by the nucleophilic cyanide ion (CN^-) breaks the carbon-oxygen pi bond, generating a tetrahedral alkoxide intermediate with four sigma bonds and sp^3 hybridization.

Why other options are incorrect:

- Option A:** The carbonyl carbon begins as sp^2 , not linear sp .
- Option B:** sp^3 to sp^2 describes an elimination reaction producing a double bond, not nucleophilic addition.
- Option D:** dsp^2 hybridization occurs in square planar transition metal complexes, not in main-group organic carbon atoms.

Question #92 Key: (C)

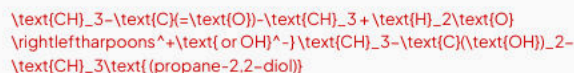
CHEMISTRY
17. Aldehydes & Ketones

Acetone reacts with water in presence of catalyst produces:

CORE CONCEPT & DERIVATION

Hydration of ketones involves reversible acid- or base-catalyzed nucleophilic addition of water across the carbonyl double bond, yielding a geminal diol (gem-diol).

Formula / Rule / Reaction:



Solution:

- Water acts as a weak nucleophile that adds to the electrophilic carbonyl carbon of propan-2-one (acetone).
- Proton transfer generates a geminal diol where two hydroxyl groups are attached to the same carbon (carbon-2), yielding propane-2,2-diol (acetone hydrate).

Why other options are incorrect:

- Option A:** Propan-2-ol is a secondary alcohol produced by catalytic hydrogenation or metal-hydride reduction of acetone, not hydration.
- Option B:** Propan-1,2-diol is a vicinal diol produced by dihydroxylation of propene.
- Option D:** Propanol (propan-1-ol) is a primary alcohol formed by reduction of propanal.

Question #93 Key: (C)

CHEMISTRY
17. Aldehydes & Ketones

Which one show positive test with Fehling solution:

CORE CONCEPT & DERIVATION

Fehling solution is a mild oxidizing agent containing an alkaline bistartratecopper(II) complex that oxidizes aliphatic aldehydes to carboxylic acid salts while precipitating brick-red copper(I) oxide.

Formula / Rule / Reaction:



Solution:

- Acetaldehyde (ethanal) is an aliphatic aldehyde readily oxidized by Fehling solution, reducing copper(II) to insoluble red copper(I) oxide (Cu_2O).
- Ketones and aromatic aldehydes lack sufficient reducing power to reduce Fehling solution under standard alkaline test conditions.

Why other options are incorrect:

- Option A:** Acetophenone is an aromatic ketone that does not undergo oxidation with Fehling reagent.
- Option B:** Metaformaldehyde (trioxane) is a cyclic trimer of formaldehyde lacking free oxidizable aldehyde functional groups.
- Option D:** Benzaldehyde is an aromatic aldehyde; resonance stabilization of the formyl group by the benzene ring prevents reaction with Fehling solution.

Question #94 Key: (B)

CHEMISTRY
12. Transition ElementsOxidation state of Tungsten in $\text{Na}_2\text{W}_4\text{O}_{13} \cdot \text{H}_2\text{O}$ is:

CORE CONCEPT & DERIVATION

The oxidation state of an element in a neutral coordination or polyoxometalate compound is calculated by equating the sum of the oxidation numbers of all constituent atoms to zero.

Formula / Rule / Reaction:

$$\sum \text{Oxidation States} = 2(+1) + 4(x) + 13(-2) + 1(0) = 0$$

Solution:

- In $\text{Na}_2\text{W}_4\text{O}_{13} \cdot \text{H}_2\text{O}$, sodium has an oxidation state of +1, oxygen is -2, and neutral water of crystallization contributes 0.
- Setting up the algebraic equation: $2(+1) + 4(x) + 13(-2) = 0 \Rightarrow 2 + 4x - 26 = 0$.
- Solving for x : $4x = 24 \Rightarrow x = +6$.

Why other options are incorrect:

- Option A:** An oxidation number of +5 would leave the polyoxometalate cluster with an uncompensated negative charge of -4.
- Option C:** +8 exceeds the maximum possible valence shell oxidation state for tungsten (group 6 transition metal).
- Option D:** Zero oxidation state is found only in elemental tungsten metal (W^0).

Question #95 Key: (D)

CHEMISTRY
08. Reaction Kinetics

Orientation of reacting molecules is important in collision theory in the following cases EXCEPT...

CORE CONCEPT & DERIVATION

According to transition state and collision theory, the steric orientation factor p governs whether colliding species collide with their reactive centers aligned; at very low pressure, collision frequency rather than complex steric orientation dominates the rate-determining behavior.

Formula / Rule / Reaction:

$$k = p \cdot Z \cdot e^{-E_a/RT} \quad (p = \text{steric or orientation factor})$$

Solution:

- Steric orientation is critical for polyatomic and structurally complex molecules, as well as under high-density/high-pressure regimes where collisions are frequent and specific alignment dictates reaction success.
- Under low pressure conditions, the mean free path is large and the overall reaction rate is limited primarily by raw collision frequency rather than stereochemical orientation constraints.

Why other options are incorrect:

- Option A:** At high pressure, collision rates are high, making correct spatial orientation the primary discriminator for successful activation.
- Option B:** Complex molecules have localized reactive sites, making steric orientation mandatory for product formation.
- Option C:** Polyatomic molecules possess multiple non-reactive bonds, requiring collisions at precise orientations to initiate bond rearrangement.

Question #96 Key: (A)

CHEMISTRY
04. Gases

Keeping temperature constant, if pressure is increased, density of gas will:

CORE CONCEPT & DERIVATION

From the ideal gas equation of state, the density of an ideal gas is directly proportional to its absolute pressure at constant temperature.

Formula / Rule / Reaction:

$$PM = \rho RT \Rightarrow \rho = \frac{PM}{RT} \Rightarrow \rho \propto P \quad (\text{at constant } T)$$

Solution:

- When pressure increases at constant temperature, gas molecules are forced closer together, decreasing the volume according to Boyle's law.
- Because mass remains constant, this reduction in volume increases the gas density ($\rho = m/V$).

Why other options are incorrect:

- Option B:** Density decreases when pressure is lowered or when temperature is raised at constant pressure.
- Option C:** Density doubles only if pressure is doubled; for an unspecified pressure increase, stating it doubles is an unsupported assumption.
- Option D:** Density remains constant only if mass and volume remain fixed in a rigid closed container.

Question #97 Key: (C)

CHEMISTRY
18. Carboxylic Acids

IUPAC name of chloroform is:

CORE CONCEPT & DERIVATION

Haloalkanes are named by prefixing the halogen substituent names onto the parent alkane chain; a one-carbon alkane substituted with three chlorine atoms is systematic trichloromethane.

Formula / Rule / Reaction:



Solution:

- Chloroform possesses the chemical formula CHCl_3 .
- The single carbon defines the parent alkane as methane, and the three chlorine atoms are designated by the prefix 'trichloro-', giving the IUPAC name trichloromethane.

Why other options are incorrect:

- Option A:** Methyl chloride is the common name for chloromethane (CH_3Cl).
- Option B:** Methyltrichloride is a non-standard, incorrect hybrid term.
- Option D:** Chloromethane is the IUPAC name for monochlorinated methane (CH_3Cl).

Question #98 Key: (B)

CHEMISTRY
14. Hydrocarbons

Which among the following will react with ammoniacal cuprous chloride:

CORE CONCEPT & DERIVATION

Terminal alkynes possess an acidic sp -hybridized terminal hydrogen that reacts with ammoniacal cuprous chloride to yield a characteristic red-brown copper acetylide precipitate.

Formula / Rule / Reaction:



Solution:

- 1-Butyne is a 1-alkyne (terminal alkyne) containing a weakly acidic terminal acetylenic hydrogen atom ($\text{C} \equiv \text{C} - \text{H}$).
- In the presence of ammoniacal cuprous chloride ($[\text{Cu}(\text{NH}_3)_2]^+$), the terminal proton is abstracted, precipitating cuprous 1-butyne as a red-brown solid.

Why other options are incorrect:

- Option A:** 1-Butene is an alkene and lacks acidic acetylenic protons, showing no reaction.
- Option C:** 2-Butene is an alkene and does not react with ammoniacal copper(I) reagent.
- Option D:** 2-Butyne is an internal alkyne ($\text{CH}_3 - \text{C} \equiv \text{C} - \text{CH}_3$) lacking terminal acetylenic hydrogens.

Question #99 Key: (C)

CHEMISTRY
06. Solids

Which of the following is not a crystalline solid?

CORE CONCEPT & DERIVATION

Crystalline solids exhibit long-range periodic order with sharp melting points, whereas amorphous solids lack regular three-dimensional atomic lattice symmetry.

Formula / Rule / Reaction:

Qualitative concept / Solid-state structural classification.

Solution:

- Glass is an amorphous supercooled liquid consisting of an irregular, disordered network of silicate tetrahedra without long-range periodicity.
- It softens gradually over a broad temperature range rather than exhibiting a sharp, well-defined melting point.

Why other options are incorrect:

- Option A:** Potassium chloride (KCl) is an ionic crystalline solid with a face-centered cubic lattice.
- Option B:** Iron metal (Fe) is a crystalline metallic solid adopting a body-centered cubic lattice at room temperature.
- Option D:** Rhombic sulfur is a molecular crystalline allotrope composed of puckered S_8 rings packed into an orthorhombic lattice.

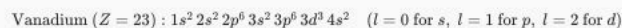
Question #100 Key: (B)

CHEMISTRY
02. Atomic StructureNumber of electron with $l=2$ in an atom having atomic number 23 is:

CORE CONCEPT & DERIVATION

The azimuthal quantum number $l = 2$ designates d-subshell orbitals; the count of electrons with $l = 2$ corresponds to the occupancy of d-orbitals in the ground-state electronic configuration.

Formula / Rule / Reaction:



Solution:

- An atom with atomic number 23 is vanadium (V).
- Following the Aufbau principle, its electronic configuration is $[\text{Ar}] 3d^3 4s^2$.
- Electrons characterized by $l = 2$ are located exclusively in the 3d subshell, which contains exactly 3 electrons.

Why other options are incorrect:

- Option A:** 2 is the number of electrons in the 4s subshell (where $l = 0$).
- Option C:** 4 electrons with $l = 2$ would correspond to chromium's theoretical unpromoted configuration.
- Option D:** 5 electrons with $l = 2$ corresponds to manganese ($[\text{Ar}] 3d^5 4s^2$).

Question #101 Key: (C)

CHEMISTRY
08. Reaction Kinetics

Reaction having high activation energy are:

CORE CONCEPT & DERIVATION

According to the Arrhenius equation, the reaction rate constant depends exponentially on the activation energy; high activation energy barriers result in smaller rate constants and slower reaction velocities.

Formula / Rule / Reaction:

$$k = Ae^{-E_a/RT} \Rightarrow \uparrow E_a \Rightarrow \downarrow k \Rightarrow \text{Slow reaction}$$

Solution:

- Activation energy (E_a) represents the minimum kinetic energy reactant molecules must possess to overcome the transition state barrier.
- A high activation energy means only a tiny fraction of colliding molecules possess sufficient energy, causing the overall reaction to proceed slowly at standard temperatures.

Why other options are incorrect:

- **Option A:** Spontaneity is governed by Gibbs free energy change ($\Delta G < 0$), not kinetic activation energy.
- **Option B:** Fast reactions are characterized by low activation energies where many collisions are fruitful.
- **Option D:** High activation energies occur in both exothermic reactions (e.g., combustion of coal) and endothermic reactions.

Question #102 Key: (A)

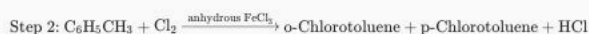
CHEMISTRY
14. Hydrocarbons

Which of the following reagents is used to convert benzene to 2-chloro methyl benzene?

CORE CONCEPT & DERIVATION

Synthesis of 2-chlorotoluene (2-chloro methyl benzene) requires introducing a methyl directing group via Friedel-Crafts alkylation, followed by ortho-directed electrophilic aromatic chlorination using a Lewis acid catalyst.

Formula / Rule / Reaction:



Solution:

- Alkylation of benzene with $CH_3Cl/AlCl_3$ yields toluene.
- The methyl group is activating and ortho/para-directing; subsequent chlorination with Cl_2 and $FeCl_3$ directs chlorine to the ortho position to yield 2-chlorotoluene.

Why other options are incorrect:

- **Option B:** Cl_2 in diffused sunlight causes free-radical side-chain halogenation of toluene, producing benzyl chloride ($C_6H_5CH_2Cl$).
- **Option C:** Chlorinating benzene first gives chlorobenzene; chlorine is deactivating and makes subsequent Friedel-Crafts alkylation slow and inefficient.
- **Option D:** Cl_2/UV causes free-radical addition to benzene, producing benzene hexachloride.

Question #103 Key: (A)

CHEMISTRY
04. Gases

According to the Kinetic molecular theory, the kinetic energy of gas molecules increases when t...

CORE CONCEPT & DERIVATION

According to Kinetic Molecular Theory, the average translational kinetic energy of molecules is directly proportional to absolute temperature; phase transitions that absorb heat energy increase molecular kinetic motion.

Formula / Rule / Reaction:

$$\overline{KE} = \frac{3}{2}k_B T \Rightarrow \overline{KE} \propto T$$

Solution:

- Melting is an endothermic phase transition where thermal energy is absorbed by the substance.
- This absorbed thermal energy disrupts the rigid crystal lattice and increases the translational and vibrational kinetic energy of the molecules.

Why other options are incorrect:

- **Option B:** Mixing with molecules at lower temperatures decreases average kinetic energy via thermal equilibration.
- **Option C:** Freezing releases latent heat, decreasing molecular kinetic energy.
- **Option D:** Condensation is an exothermic phase change that lowers molecular kinetic energy.

Question #104 Key: (D)

CHEMISTRY
07. EquilibriumIf the equilibrium expression of a reversible reaction is $[C]^2/[A][B]$. The balanced chemical eq...

CORE CONCEPT & DERIVATION

According to the Law of Mass Action, the equilibrium constant expression K_c places product concentrations in the numerator and reactant concentrations in the denominator, each raised to the power of its stoichiometric coefficient.

Formula / Rule / Reaction:

$$aA + bB \rightleftharpoons cC \Rightarrow K_c = \frac{[C]^c}{[A]^a[B]^b}$$

Solution:

- The given expression is $K_c = \frac{[C]^2}{[A][B]}$.
- The numerator $[C]^2$ indicates that 2 moles of product C are formed, while the denominator $[A][B]$ indicates that 1 mole of A and 1 mole of B are consumed.
- Matching stoichiometry yields the balanced equation: $A + B \rightleftharpoons 2C$.

Why other options are incorrect:

- **Option A:** For $C \rightleftharpoons A + B$, the expression would be $K_c = [A][B]/[C]$.
- **Option B:** For $2C \rightleftharpoons A + B$, the expression would be $K_c = [A][B]/[C]^2$.
- **Option C:** For $A + B \rightleftharpoons C$, the expression would be $K_c = [C]/([A][B])$.

Question #105 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

Common name of 1,3 benzene diol is:

CORE CONCEPT & DERIVATION

Benzenediols are aromatic dihydroxy compounds with three positional isomers: 1,2-benzenediol (catechol), 1,3-benzenediol (resorcinol), and 1,4-benzenediol (hydroquinone/quinol).

Formula / Rule / Reaction:



Solution:

- 1,3-Benzenediol has two hydroxyl groups attached meta to each other on the benzene ring.
- Its IUPAC-accepted common trivial name is resorcinol.

Why other options are incorrect:

- Option A:** Pyrogallol is 1,2,3-trihydroxybenzene, a benzenetriol.
- Option B:** Cresol refers to methylphenols (hydroxytoluenes), containing one $-\text{OH}$ and one $-\text{CH}_3$ group.
- Option D:** Catechol is the common name for 1,2-benzenediol (ortho isomer).

Question #106 Key: (C)

CHEMISTRY
03. Chemical Bonding

How many sigma and pi bonds are present in maleic anhydride?

CORE CONCEPT & DERIVATION

Maleic anhydride is a cyclic dicarboxylic acid anhydride ($\text{C}_4\text{H}_2\text{O}_3$); its total sigma bonds equal the sum of its single bonds plus one per double bond, and its pi bonds correspond to the double bonds.

Formula / Rule / Reaction:



Solution:

- Pi (π) bonds: One in the $\text{C} = \text{C}$ bond and one in each of the two $\text{C} = \text{O}$ carbonyl groups, giving $1 + 2 = 3$ π bonds.
- Sigma (σ) bonds: Two $\text{C} - \text{H}$ single bonds (2), two $\text{C} - \text{C}$ single bonds (2), two $\text{C} - \text{O}$ ring single bonds (2), one σ from $\text{C} = \text{C}$ (1), and two σ from the two $\text{C} = \text{O}$ groups (2), giving $2 + 2 + 2 + 1 + 2 = 9$ σ bonds.

Why other options are incorrect:

- Option A:** Omits the sigma components of ring single bonds and $\text{C} - \text{H}$ bonds.
- Option B:** Neglects the sigma bonds in the carbonyl linkages.
- Option D:** Overcounts total sigma bonds by treating pi bonds as additional sigma linkages.

Question #107 Key: (A)

CHEMISTRY
14. Hydrocarbons

Addition of three molecules of chlorine into benzene prove that benzene has

CORE CONCEPT & DERIVATION

Under ultraviolet radiation, benzene undergoes exhaustive free-radical addition of three halogen molecules, confirming the presence of three conjugated double bonds in its Kekule representation.

Formula / Rule / Reaction:



Solution:

- Each molecule of chlorine (Cl_2) adds across one carbon-carbon double bond.
- The consumption of exactly three chlorine molecules to form saturated 1,2,3,4,5,6-hexachlorocyclohexane proves that benzene possesses three pairs of shared pi electrons (three double bonds).

Why other options are incorrect:

- Option B:** While benzene is nonpolar due to symmetry, stoichiometry of chlorine addition does not establish polarity.
- Option C:** Benzene is a nonpolar hydrocarbon.
- Option D:** Benzene is a planar aromatic ring with sp^2 hybridization.

Question #108 Key: (C)

CHEMISTRY
14. Hydrocarbons

Propyne is allowed to react with hydrochloric acid two times then final product is

CORE CONCEPT & DERIVATION

Electrophilic addition of hydrogen halides to unsymmetrical alkynes follows Markovnikov's rule in both sequential steps, directing both halogen atoms to the more substituted internal carbon.

Formula / Rule / Reaction:



Solution:

- In step 1, the proton electrophile adds to carbon-1 to form the more stable secondary carbocation, followed by chloride attack to give 2-chloropropene.
- In step 2, Markovnikov addition repeats because carbocation intermediate stability is enhanced by resonance donation from the chlorine lone pair, directing the second chlorine to carbon-2 to yield 2,2-dichloropropane.

Why other options are incorrect:

- Option A:** 1,1-Dichloropropane requires anti-Markovnikov addition in both steps.
- Option B:** 1,2-Dichloropropane requires addition of chlorine gas (Cl_2) followed by hydrogenation, not hydrochlorination.
- Option D:** 1,2-Dichloropropene is an intermediate monochloroalkene that forms from halogenation, not the saturated product of two HCl additions.

Question #109 Key: (C)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Diethyl ether and Methyl n-propyl ether are

CORE CONCEPT & DERIVATION

Metamerism is constitutional isomerism exhibited by compounds having the same functional group and molecular formula but differing in the alkyl groups attached to the central polyvalent heteroatom.

Formula / Rule / Reaction:

Diethyl ether: $\text{C}_2\text{H}_5 - \text{O} - \text{C}_2\text{H}_5$ vs. Methyl n-propyl ether: $\text{CH}_3 - \text{O} - \text{CH}_2\text{CH}_2\text{CH}_3$

Solution:

- Both ethers share the identical molecular formula $\text{C}_4\text{H}_{10}\text{O}$ and the same ether functional group ($-\text{O}-$).
- They differ in the distribution of carbon atoms around the divalent oxygen atom (ethyl + ethyl vs. methyl + propyl), classifying them as metamers.

Why other options are incorrect:

- Option A:** Position isomers possess the same carbon skeleton but differ in the position of a substituent or functional group along the chain.
- Option B:** Functional group isomers possess different functional groups (e.g., diethyl ether and butan-1-ol).
- Option D:** Tautomers are constitutional isomers that interconvert rapidly through dynamic proton transfer.

Question #110 Key: (B)

CHEMISTRY
18. Carboxylic AcidsIn the given reaction $\text{CH}_3\text{OH} \rightarrow \text{HCOOH}$, oxidation state of carbon changes from:

CORE CONCEPT & DERIVATION

The oxidation state of carbon in an organic compound is determined by assigning standard oxidation numbers to attached atoms (+1 for H, -2 for O) and balancing the total molecular charge to zero.

Formula / Rule / Reaction:

$$\text{In } \text{CH}_3\text{OH} : x + 4(+1) + 1(-2) = 0 \Rightarrow x = -2$$

$$\text{In } \text{HCOOH} : x + 2(+1) + 2(-2) = 0 \Rightarrow x = +2$$

Solution:

- In methanol (CH_3OH), carbon is bonded to three hydrogens, one oxygen, and shares a proton: $x + 4 - 2 = 0 \Rightarrow x = -2$.
- In formic acid (HCOOH), carbon is bonded to one hydrogen, one hydroxyl group, and double-bonded to oxygen: $x + 2 - 4 = 0 \Rightarrow x = +2$.
- The net change in carbon's oxidation state is from -2 to +2 (loss of 4 electrons).

Why other options are incorrect:

- Option A:** 0 is the oxidation state of carbon in formaldehyde (HCHO).
- Option C:** -3 is the oxidation state of carbon in ethane (C_2H_6).
- Option D:** Carbon in methanol has an oxidation state of -2, not 0.

Question #111 Key: (B)

CHEMISTRY
09. Thermochemistry

For endothermic reaction, enthalpy change is:

CORE CONCEPT & DERIVATION

An endothermic reaction absorbs heat from its surroundings, yielding products that possess a higher total enthalpy content than the reactants.

Formula / Rule / Reaction:

$$\Delta H_{\text{rxn}} = H_{\text{products}} - H_{\text{reactants}} > 0 \Rightarrow H_{\text{reactants}} < H_{\text{products}}$$

Solution:

- Because system enthalpy increases as thermal energy is converted into chemical potential energy, ΔH is positive.
- This thermodynamic requirement means the enthalpy of reactants is less than the enthalpy of products ($H_{\text{reactant}} < H_{\text{product}}$).

Why other options are incorrect:

- Option A:** $H_{\text{reactant}} > H_{\text{product}}$ defines an exothermic reaction where enthalpy is released.
- Option C:** Equal reactant and product enthalpy means $\Delta H = 0$, describing a thermoneutral process.
- Option D:** Absolute zero enthalpy is not characteristic of chemical systems.

Question #112 Key: (D)

CHEMISTRY
16. Alcohols & Phenols

The structure of four Chloroalkanes W, X, Y and Z are shown: W: $(\text{CH}_3)_2\text{CHCH}(\text{Cl})\text{CH}_3$ X: $\text{CH}_2(\text{Cl})\text{CH}_3$...

CORE CONCEPT & DERIVATION

A tertiary (3°) chloroalkane is one in which the halogen-bearing carbon atom is directly bonded to three other carbon atoms.

Formula / Rule / Reaction:

Tertiary Carbon: $\text{R}_3\text{C} - \text{Cl}$ (bonded to 3 alkyl carbons)

Solution:

- In compound Z, $(\text{CH}_3)_2\text{CHCH}(\text{CH}_3)_2$, the chlorine-bearing carbon is directly bonded to two methyl groups and one isopropyl group (three carbon atoms), making it tertiary.
- W, $(\text{CH}_3)_2\text{CHCH}(\text{Cl})\text{CH}_3$, has its chlorine attached to a secondary carbon bonded to two carbons.
- X (chloroethane) and Y (neopentyl chloride) have chlorines attached to primary carbons bonded to only one carbon.

Why other options are incorrect:

- Option A:** W is a secondary (2°) chloroalkane.
- Option B:** X is a primary (1°) chloroalkane.
- Option C:** Y is a primary (1°) chloroalkane with a bulky tert-butyl substituent.

Question #113 Key: (C)

CHEMISTRY
06. Solids

The smallest repeating pattern from which the lattice is built in a crystalline solid is called

CORE CONCEPT & DERIVATION

The unit cell is the fundamental geometric structural unit of a crystalline solid that, when repeated translationally in three dimensions, generates the entire macroscopic crystal lattice.

Formula / Rule / Reaction:

Qualitative concept / Crystallography.

Solution:

- A crystal lattice is an infinite three-dimensional array of points in space.
- The unit cell is the smallest repeating parallel-piped block displaying the full symmetry and stoichiometry of the chemical crystal.

Why other options are incorrect:

- **Option A:** A crystallite is a microscopic domain or single-crystal grain in a polycrystalline material.
- **Option B:** An amorphous region lacks regular repeating structure.
- **Option D:** The crystal lattice is the complete three-dimensional network produced by repeating the unit cell.

Question #114 Key: (A)

CHEMISTRY
07. Equilibrium

Which of the following reaction will move backward by decreasing pressure?

CORE CONCEPT & DERIVATION

According to Le Chatelier's principle, decreasing pressure shifts a gaseous equilibrium toward the side with the greater number of gaseous moles.

Formula / Rule / Reaction:

$$\Delta n_g = n_{\text{products}} - n_{\text{reactants}}; \downarrow P \Rightarrow \text{Shift toward side with larger } n_g$$

Solution:

- In reaction A ($4Q \rightleftharpoons T + S$), the reactant side has 4 moles of gas while the product side has 2 moles of gas.
- Decreasing pressure favors the side with more gaseous moles; therefore, the system shifts backward toward reactants (left) to relieve the decrease in pressure.

Why other options are incorrect:

- **Option B:** $2A \rightleftharpoons 3C$ has more moles on the product side (3 vs. 2), so decreasing pressure shifts it forward.
- **Option C:** $K \rightleftharpoons L$ has equal moles on both sides (1 vs. 1), making it insensitive to pressure changes.
- **Option D:** $H + 2M \rightleftharpoons 2B + 2D$ has 3 reactant moles and 4 product moles, shifting forward when pressure is decreased.

Question #115 Key: (B)

CHEMISTRY
07. Equilibrium

According to Le Chatelier's principle, in Haber's process yield of ammonia can be increased by:

CORE CONCEPT & DERIVATION

The synthesis of ammonia via the Haber process is an exothermic gas reaction accompanied by a reduction in total gaseous moles; higher pressure and lower temperature shift equilibrium toward product formation.

Formula / Rule / Reaction:



Solution:

- Because 4 moles of reactants yield 2 moles of product, increasing total pressure shifts the system forward to minimize volume.
- Because the forward reaction is exothermic, lowering the operating temperature shifts equilibrium toward the right, increasing the equilibrium yield of NH_3 .

Why other options are incorrect:

- **Option A:** Decreasing pressure shifts equilibrium backward, while increasing temperature favors the endothermic decomposition of ammonia.
- **Option C:** Increasing volume is equivalent to lowering pressure, which reduces ammonia yield.
- **Option D:** Decreasing reactant concentration (H_2) shifts the equilibrium backward toward reactants.

Question #116 Key: (C)

CHEMISTRY
04. Gases

Hyperbola isotherm is obtained when graph is plotted between:

CORE CONCEPT & DERIVATION

Boyle's law establishes that gas pressure is inversely proportional to volume at constant temperature, producing a rectangular hyperbola when pressure is plotted directly against volume.

Formula / Rule / Reaction:

$$P \cdot V = k \Rightarrow P = \frac{k}{V} \quad (xy = c, \text{ standard equation of a rectangular hyperbola})$$

Solution:

- An isotherm represents thermodynamic state variables measured at constant temperature.
- Plotting P along the vertical axis against V along the horizontal axis produces a smooth, asymptotic curved hyperbolic isotherm.

Why other options are incorrect:

- **Option A:** Plotting P against $1/V$ yields a straight line passing through the origin.
- **Option B:** Plotting PV against V yields a horizontal straight line parallel to the volume axis.
- **Option D:** Plotting V against $1/P$ produces a linear relationship passing through the origin.

Question #117 Key: (C)

CHEMISTRY
02. Atomic Structure

Highest energy for one quantum among radiation is:

CORE CONCEPT & DERIVATION

The energy of a single photon quantum is directly proportional to its electromagnetic frequency and inversely proportional to its wavelength.

Formula / Rule / Reaction:

$$E = h\nu = \frac{hc}{\lambda} \implies E_{UV} > E_{\text{visible}} > E_{IR} > E_{\text{microwave}}$$

Solution:

- Ultraviolet radiation has wavelengths ranging from 10 to 400 nm, corresponding to higher frequencies and energies per photon than visible, infrared, or microwave radiation.
- Because ultraviolet radiation has the shortest wavelength among the listed choices, each of its quanta carries the highest energy.

Why other options are incorrect:

- Option A:** Microwaves have long wavelengths (millimeters to centimeters) and very low quantum energies.
- Option B:** Infrared radiation has lower frequencies and lower photon energies than visible and UV light.
- Option D:** Visible light (400 to 700 nm) has longer wavelengths and lower photon energies than ultraviolet radiation.

Question #118 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones

Which of the following reagent is commonly used to prepare alkyne from vicinal dihalide?

CORE CONCEPT & DERIVATION

Vicinal dihalides undergo sequential double dehydrohalogenation in the presence of strong bases to eliminate two equivalents of hydrogen halide, producing an alkyne.

Formula / Rule / Reaction:



Solution:

- Initial dehydrohalogenation with hot alcoholic potassium hydroxide (KOH) eliminates one molecule of HX to yield a haloalkene.
- Because the haloalkene is less reactive toward elimination, the stronger base sodamide (NaNH₂) is employed to eliminate the second HX and generate the carbon-carbon triple bond.

Why other options are incorrect:

- Option A:** Hydrogen gas with a metal catalyst reduces alkynes to alkanes, rather than synthesizing alkynes.
- Option C:** Potassium permanganate (KMnO₄) is an oxidizing agent that cleaves double and triple bonds.
- Option D:** Lithium aluminium hydride reduces carbonyls and alkyl halides to alkanes.

Question #119 Key: (B)

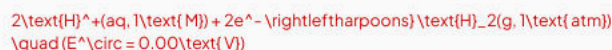
CHEMISTRY
10. Electrochemistry

In a standard hydrogen electrode, the platinum electrode:

CORE CONCEPT & DERIVATION

In the Standard Hydrogen Electrode (SHE), platinum functions as an inert conducting catalyst that facilitates electron transfer between adsorbed hydrogen gas and hydrogen ions without reacting chemically.

Formula / Rule / Reaction:



Solution:

- Platinum foil coated with finely divided platinum black provides a large surface area for the adsorption of H₂ molecules.
- It serves as an electron conductor facilitating oxidation (H₂ → 2H⁺ + 2e⁻) or reduction (2H⁺ + 2e⁻ → H₂), establishing dynamic redox equilibrium.

Why other options are incorrect:

- Option A:** Platinum is a noble, chemically inert metal that does not react with hydrogen gas.
- Option C:** A salt bridge consists of an electrolyte gel (e.g., KCl in agar) that maintains electrical neutrality between half-cells.
- Option D:** The standard hydrogen electrode is arbitrarily assigned a reference potential of 0.00 V and does not supply voltage on its own.

Question #120 Key: (B)

CHEMISTRY
06. Solids

Which of the following compound has lower Lattice Energy?

CORE CONCEPT & DERIVATION

Lattice energy of an ionic crystal is directly proportional to ionic charge product and inversely proportional to internuclear separation distance between the ions.

Formula / Rule / Reaction:

$$U \propto \frac{|z^+ \cdot z^-|}{r_c + r_a}$$

Solution:

- Between LiCl and KCl, both compounds have monovalent ions (+1 and -1), but the ionic radius of potassium (K⁺) is significantly larger than that of lithium (Li⁺).
- The larger internuclear distance in KCl reduces electrostatic attraction, giving KCl a lower lattice energy than LiCl.
- CaCl₂ contains a divalent cation (Ca²⁺), resulting in a much higher lattice energy.

Why other options are incorrect:

- Option A:** LiCl has a smaller cation radius than KCl, resulting in higher lattice energy.
- Option C:** CaCl₂ possesses a divalent Ca²⁺ cation, giving it a much higher lattice energy.
- Option D:** Glucose is a covalent molecular solid held by intermolecular forces, not an ionic lattice.

Question #121 Key: (B)

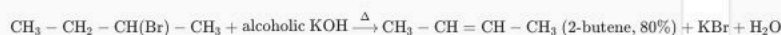
CHEMISTRY
14. Hydrocarbons

Reaction of 2-Bromobutane with alcoholic KOH yields:

CORE CONCEPT & DERIVATION

Reaction of a haloalkane with hot alcoholic potassium hydroxide induces dehydrohalogenation via an E2 mechanism, selectively producing the more substituted alkene as the major product (Saytzeff's rule).

Formula / Rule / Reaction:



Solution:

- Alcoholic KOH acts as a strong base that abstracts a beta-hydrogen from carbon-3 while bromide departs from carbon-2.
- According to Saytzeff's rule, beta-elimination yields the more substituted and thermodynamically stable alkene (but-2-ene) as the major product.

Why other options are incorrect:

- Option A:** 2-Butanol is formed via nucleophilic substitution ($\text{S}_{\text{N}}2$) using aqueous KOH, not alcoholic KOH.
- Option C:** Formation of 2-butyne requires a dihaloalkane precursor undergoing double elimination.
- Option D:** 1-Butanol is synthesized by nucleophilic substitution of 1-bromobutane.

Question #123 Key: (C)

CHEMISTRY
08. Reaction Kinetics

The rate of reaction for a zero-order reaction:

CORE CONCEPT & DERIVATION

In a zero-order reaction, the reaction rate is independent of the concentrations of the reactants, remaining constant throughout the course of the reaction until the reactants are exhausted.

Formula / Rule / Reaction:

$$\text{Rate} = k[\text{A}]^0 = k = \text{constant}$$

Solution:

- The differential rate law for a zero-order reaction is $-\frac{d[\text{A}]}{dt} = k$.
- Because the rate constant k depends only on temperature and catalyst presence, the velocity of the reaction remains unchanged over time as reactant is consumed.

Why other options are incorrect:

- Option A:** Reaction rate does not increase unless catalyzed autocatalytically or temperature is raised.
- Option B:** A decreasing rate over time is characteristic of first-order, second-order, and higher-order reactions where rate depends on concentration.
- Option D:** The rate of an isothermal zero-order reaction is constant, not variable.

Question #122 Key: (D)

CHEMISTRY
12. Transition Elements

Which species contain an element with an oxidation number of +4?

CORE CONCEPT & DERIVATION

The oxidation state of an atom in an oxoanion or neutral salt is determined using known oxidation rules (+1 for alkali metals, -2 for oxygen).

Formula / Rule / Reaction:

$$\text{In } \text{Na}_2\text{CO}_3 : 2(+1) + x + 3(-2) = 0 \Rightarrow 2 + x - 6 = 0 \Rightarrow x = +4$$

Solution:

- In sodium carbonate (Na_2CO_3), sodium contributes +2 and three oxygens contribute -6.
- To maintain electrical neutrality, carbon must have an oxidation state of +4.

Why other options are incorrect:

- Option A:** In chromate (CrO_4^{2-}), chromium has an oxidation state of +6: $x + 4(-2) = -2 \Rightarrow x = +6$.
- Option B:** In manganate (MnO_4^{2-}), manganese has an oxidation state of +6: $x + 4(-2) = -2 \Rightarrow x = +6$.
- Option C:** In sulfuric acid (H_2SO_4), sulfur has an oxidation state of +6: $2(+1) + x + 4(-2) = 0 \Rightarrow x = +6$.

Question #124 Key: (C)

CHEMISTRY
08. Reaction Kinetics

The order of chemical reaction is defined as:

CORE CONCEPT & DERIVATION

The order of a chemical reaction with respect to a given reactant is the exponent to which its concentration term is raised in the experimentally determined rate equation.

Formula / Rule / Reaction:

$$\text{Rate} = k[\text{A}]^m[\text{B}]^n \Rightarrow m = \text{order with respect to A; } (m + n) = \text{overall order}$$

Solution:

- The rate equation expresses reaction velocity as a function of reactant concentrations raised to empirical powers.
- These powers (exponents) represent the reaction orders, which are experimentally determined and cannot be deduced simply from balanced stoichiometric coefficients.

Why other options are incorrect:

- Option A:** The stoichiometric count of reactants in a balanced chemical equation defines stoichiometric molecularity, not kinetic reaction order.
- Option B:** The number of products formed does not determine reaction order.
- Option D:** The rate constant (k) is the proportionality constant in the rate law, not the order.

Question #125 Key: (B)

CHEMISTRY
04. Gases

Real gases show more positive deviation as pressure increases because of

CORE CONCEPT & DERIVATION

At high pressures, gas molecules are forced close together, making intermolecular repulsive forces and finite molecular volume dominant, which drives the compressibility factor $Z > 1$ (positive deviation).

Formula / Rule / Reaction:

$$Z = \frac{PV}{nRT} > 1 \quad (\text{dominated by the excluded volume parameter } b \text{ and repulsive forces})$$

Solution:

- At low to moderate pressures, attractive forces dominate, pulling molecules together and producing negative deviations ($Z < 1$).
- At high pressures, the physical volume occupied by molecules becomes significant relative to container volume, and electronic repulsion resists further compression, causing the molar volume to exceed ideal predictions (positive deviation).

Why other options are incorrect:

- Option A:** Real gases consist of neutral covalent atoms or molecules, not ionic species.
- Option C:** Attractive forces cause negative deviations ($Z < 1$) at moderate pressures.
- Option D:** Nonpolar gases experience dispersion forces, but polarity is not the primary cause of high-pressure positive deviation.

Question #126 Key: (B)

CHEMISTRY
04. Gases

Which statement applies to both ideal and real gases

CORE CONCEPT & DERIVATION

A fundamental postulate of Kinetic Molecular Theory that applies to all gases is that gas molecules are in continuous, random, chaotic motion in all directions.

Formula / Rule / Reaction:

Fundamental Postulate of Gas Kinetics: Continuous, random, Brownian translational motion.

Solution:

- Thermal energy ensures that particles of both ideal and real gases undergo continuous, rapid, straight-line random motion interrupted only by collisions.
- This property is universal across ideal models and real fluids.

Why other options are incorrect:

- Option A:** Perfectly elastic collisions without net kinetic energy loss are an idealized assumption; real molecular collisions involve temporary deformation and energy redistribution.
- Option C:** Intermolecular attractive forces exist only in real gases, being neglected in ideal gases.
- Option D:** Zero molecular volume is an idealized assumption; real gas particles occupy a finite volume.

Question #127 Key: (D)

PHYSICS
09. Current Electricity

If voltage across a resistor is doubled then its resistance will become: (temperature and physi...

CORE CONCEPT & DERIVATION

Electrical resistance of an ohmic conductor is an intrinsic geometric and material property defined by resistivity, length, and cross-sectional area, remaining independent of applied voltage at constant temperature.

Formula / Rule / Reaction:

$$R = \rho \frac{L}{A} \quad (\text{independent of } V \text{ and } I \text{ for an ohmic resistor})$$

Solution:

- According to Ohm's law, $V = IR$. When voltage V is doubled, the current I flowing through the conductor doubles proportionally.
- Because resistance depends on the physical dimensions and resistivity of the conductor, R remains constant as long as temperature and physical state are unchanged.

Why other options are incorrect:

- Option A:** Doubling voltage increases the current, not the resistance.
- Option B:** Halving resistance would require changing the physical dimensions or material of the conductor.
- Option C:** Resistance does not scale quadratically with voltage.

Question #128 Key: (A)

PHYSICS
05. Waves

A particle is moving in a uniform circular path whose projection is executing simple harmonic m...

CORE CONCEPT & DERIVATION

The projection of uniform circular motion along a diameter executes simple harmonic motion, achieving its maximum instantaneous velocity when passing through the center (mean equilibrium position).

Formula / Rule / Reaction:

$$v(x) = \omega \sqrt{A^2 - x^2}; \quad \text{At the center } (x = 0): v = \omega A = v_{\max}$$

Solution:

- The instantaneous velocity of the projection is given by $v = \omega \sqrt{A^2 - x^2}$.
- At the center of the diameter, the displacement is zero ($x = 0$), meaning the instantaneous velocity equals the maximum velocity: $v_{\text{inst}} = \omega A = v_{\max}$.
- The ratio of instantaneous velocity to maximum velocity at this point is $v_{\max} : v_{\text{inst}} = 1 : 1$.

Why other options are incorrect:

- Option B:** 1:2 occurs at a displacement of $x = \frac{\sqrt{3}}{2}A$, not at the center.
- Option C:** Instantaneous velocity can never exceed maximum velocity in simple harmonic motion.
- Option D:** 1:4 corresponds to an instantaneous velocity near the extreme displacement points.

Question #129 Key: (C)

PHYSICS
05. Waves

The option that shows the conditions used by Laplace for connecting the velocity of sound is op...

CORE CONCEPT & DERIVATION

Laplace corrected Newton's formula for the speed of sound by recognizing that rapid compressions and rarefactions in a gas occur adiabatically, without significant heat exchange with the surrounding medium.

Formula / Rule / Reaction:

$$v_{\text{Laplace}} = \sqrt{\frac{\gamma P}{\rho}} \quad (\gamma = C_p/C_v, \text{ adiabatic bulk modulus } E_s = \gamma P)$$

Solution:

- Newton incorrectly assumed that acoustic compressions and rarefactions in a gas occurred isothermally.
- Laplace recognized that sound waves propagate so rapidly that thermal conduction is negligible, meaning acoustic pressure fluctuations in a gas take place under adiabatic conditions.

Why other options are incorrect:

- **Option A:** Laplace's correction specifically addressed acoustic propagation in gases, not solids.
- **Option B:** Sound propagation does not occur under isobaric (constant pressure) conditions.
- **Option D:** An isothermal gas process was Newton's original assumption, which underestimated the measured speed of sound in air by approximately 16%.

Question #130 Key: (A)

PHYSICS
14. Dawn of Modern Physics

If different colored light beams have same total energy, which color beam will contain the smallest...

CORE CONCEPT & DERIVATION

Total radiant energy is the product of photon count and single-photon energy; because photon energy is directly proportional to frequency, the color with the highest frequency requires the fewest photons to attain a given total energy.

Formula / Rule / Reaction:

$$E_{\text{total}} = N \cdot E_{\text{photon}} = N \cdot \frac{hc}{\lambda} \implies N = \frac{E_{\text{total}} \cdot \lambda}{hc}$$

Solution:

- Violet light has the shortest wavelength ($\lambda \approx 400 \text{ nm}$) and the highest frequency among visible colors, giving each violet photon the highest individual energy.
- For a fixed total energy E_{total} , the beam composed of higher-energy photons requires the smallest total number of photons N .

Why other options are incorrect:

- **Option B:** Blue light has a longer wavelength and lower photon energy than violet light, requiring more photons.
- **Option C:** Green light has intermediate photon energy and requires more photons than violet.
- **Option D:** Red light has the longest wavelength and lowest photon energy in the visible spectrum, requiring the largest number of photons.

Question #131 Key: (D)

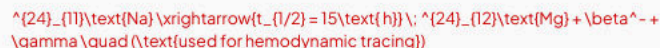
PHYSICS
16. Nuclear Physics

A patient is injected with a radioactive isotope to trace blood flow and detect circulation iss...

CORE CONCEPT & DERIVATION

Sodium-24 is a gamma-emitting radiotracer with a short half-life (15 hours) that behaves physiologically like natural sodium in blood plasma, making it suitable for diagnosing circulatory disorders.

Formula / Rule / Reaction:



Solution:

- Injected as a sterile isotonic saline solution (${}^{24}\text{NaCl}$), sodium-24 distributes evenly throughout the vascular system.
- Detecting its emitted gamma radiation with external scintillation counters allows clinicians to trace blood flow velocity and identify site-specific circulatory obstructions.

Why other options are incorrect:

- **Option A:** Iodine-131 concentrates in the thyroid gland to treat and diagnose thyroid disorders.
- **Option B:** Phosphorus-32 is a pure beta emitter used to treat polycythemia vera and label nucleic acids.
- **Option C:** Cobalt-60 is a high-energy gamma source used for external beam radiotherapy, not as an internal hemodynamic tracer.

Question #132 Key: (C)

PHYSICS
06. Fluid Dynamics

Water flows through a pipe of 0.02 m^2 with a speed of 3 m/s . The pipe narrows to 0.01 m^2 . The s...

CORE CONCEPT & DERIVATION

For an incompressible, steady fluid flow, the equation of continuity dictates that the product of cross-sectional area and fluid velocity remains constant along a streamline.

Formula / Rule / Reaction:

$$A_1 v_1 = A_2 v_2 \implies v_2 = v_1 \left(\frac{A_1}{A_2} \right)$$

Solution:

- Given values: $A_1 = 0.02 \text{ m}^2$, $v_1 = 3 \text{ m/s}$, and $A_2 = 0.01 \text{ m}^2$.
- Substitute into the continuity equation: $0.02 \times 3 = 0.01 \times v_2$.
- Solve for v_2 : $v_2 = \frac{0.06}{0.01} = 6 \text{ m/s}$.

Why other options are incorrect:

- **Option A:** 1.5 m/s would result if the pipe expanded to double its area.
- **Option B:** 3 m/s would mean no change in cross-sectional area occurred.
- **Option D:** 9 m/s would require the area to decrease to one-third of its original value.

Question #133 Key: (C)PHYSICS
06. Fluid Dynamics

In the human circulatory system, turbulent blood flow is most likely to occur when the:

CORE CONCEPT & DERIVATION

Fluid turbulence is governed by the Reynolds number; when blood encounters an obstruction in a narrowed or clogged vessel, flow velocity increases locally and produces eddies and vortices.

Formula / Rule / Reaction:

$$N_R = \frac{\rho v D}{\eta} \quad (N_R > 2000 \Rightarrow \text{Turbulent Flow})$$

Solution:

- Atherosclerotic plaques or partial obstructions constrict the vessel lumen, forcing blood through the constriction at high localized velocities.
- The resulting flow separation and velocity shear exceed the critical Reynolds number, generating turbulent vortices heard clinically as bruits or murmurs.

Why other options are incorrect:

- **Option A:** Very small vessel diameters (e.g., in capillaries) keep the Reynolds number low, maintaining laminar flow.
- **Option B:** Low velocity lowers the Reynolds number, promoting laminar flow.
- **Option D:** Increased blood viscosity increases the denominator of the Reynolds equation, stabilizing laminar flow.

Question #134 Key: (C)PHYSICS
11. Electromagnetic Induction

A conducting ring is placed near a current-carrying coil. As the current in the coil increases,...

CORE CONCEPT & DERIVATION

According to Lenz's law and Faraday's law of induction, the direction of an induced current always opposes the change in magnetic flux that produces it.

Formula / Rule / Reaction:

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

Solution:

- As current in the primary coil increases, the magnetic flux passing through the nearby conducting ring increases.
- By Lenz's law, an electromotive force is induced in the ring driving a current whose own magnetic field opposes this increase in magnetic flux.

Why other options are incorrect:

- **Option A:** Induced current flows along the circular path of the conductor, perpendicular to the magnetic field vector.
- **Option B:** Flowing to increase flux would violate the principle of conservation of energy.
- **Option D:** The induced current has a deterministic direction dictated by electromagnetic laws.

Question #135 Key: (B)PHYSICS
05. Waves

In progressive waves, energy is transferred from one point to another through:

CORE CONCEPT & DERIVATION

A progressive mechanical wave transfers energy and momentum through a medium via localized simple harmonic oscillations of particles about their fixed equilibrium positions without bulk translation of matter.

Formula / Rule / Reaction:

$$y(x, t) = A \sin(kx - \omega t) \quad (\text{Wave propagation with localized particle oscillation})$$

Solution:

- As the wave propagates, medium particles oscillate back and forth about their mean equilibrium positions.
- Elastic forces between neighboring particles transmit kinetic and potential energy along the medium while the particles themselves remain in place on average.

Why other options are incorrect:

- **Option A:** Circular particle motion is characteristic of surface water waves, not a general description of progressive waves.
- **Option C:** Rotational motion does not mediate longitudinal or transverse mechanical wave propagation.
- **Option D:** Medium particles do not undergo net translational displacement during wave transmission.

Question #136 Key: (A)PHYSICS
12. Alternating Current

A capacitor is connected to an ac source. If the frequency of the AC source is doubled the curr...

CORE CONCEPT & DERIVATION

In a purely capacitive AC circuit, capacitive reactance is inversely proportional to frequency, meaning alternating current is directly proportional to frequency.

Formula / Rule / Reaction:

$$X_C = \frac{1}{2\pi fC} \Rightarrow I_{\text{rms}} = \frac{V_{\text{rms}}}{X_C} = V_{\text{rms}}(2\pi fC) \Rightarrow I \propto f$$

Solution:

- Capacitive reactance represents the opposition offered by a capacitor to alternating current flow: $X_C = 1/(2\pi fC)$.
- When the AC frequency f is doubled to $2f$, the reactance X_C is halved.
- Consequently, for a constant applied RMS voltage, the circuit current doubles proportionally.

Why other options are incorrect:

- **Option B:** Current depends directly on alternating frequency in reactive capacitive circuits.
- **Option C:** Current halves in an inductive circuit ($I \propto 1/f$), not in a capacitive circuit.
- **Option D:** Current approaches zero as frequency approaches zero (DC limit), not when AC frequency is increased.

Question #137 **Key: (B)**PHYSICS
07. Thermodynamics

When thermal energy is transferred from a hot object to a cold one, the change occurs in the ho...

CORE CONCEPT & DERIVATION

According to the First and Second Laws of Thermodynamics, when an isolated system transfers heat spontaneously to a colder body, the donor object loses thermal energy, reducing its internal energy.

Formula / Rule / Reaction:

$$\Delta U = Q - W \quad (\text{Heat removed: } Q < 0 \implies \Delta U < 0)$$

Solution:

- Thermal energy transfers spontaneously from a region of higher temperature to one of lower temperature until thermal equilibrium is established.
- Because energy is leaving the hotter body in the form of heat, its internal kinetic and potential microscopic energy decreases ($\Delta U < 0$).

Why other options are incorrect:

- **Option A:** The hot body expels energy, making an increase in internal energy impossible.
- **Option C:** Temperature decreases proportionally with internal energy loss in the absence of phase changes.
- **Option D:** 'Heat content' is an obsolete caloric concept; thermodynamics defines heat strictly as energy in transit.

Question #138 **Key: (B)**PHYSICS
15. Atomic Spectra

Two spectral lines in the Hydrogen atom spectrum are close together. This likely means:

CORE CONCEPT & DERIVATION

The separation between spectral lines is proportional to the difference between their emission frequencies, which corresponds directly to the energy differences between the quantum transitions.

Formula / Rule / Reaction:

$$\Delta E = h\nu = \frac{hc}{\lambda} \implies |\Delta E_1 - \Delta E_2| = hc \left| \frac{1}{\lambda_1} - \frac{1}{\lambda_2} \right|$$

Solution:

- Spectral lines correspond to electronic transitions between discrete quantum energy levels.
- When two spectral lines lie very close together in wavelength space ($\Delta\lambda \approx 0$), the photons have nearly identical frequencies and energies, meaning the energy gap difference between the two transition pairs is small.
- **Note on board erratum:** Some provincial keys erroneously marked Option C; however, spectral line spacing is determined by quantum transition energy differences, not beam intensity.

Why other options are incorrect:

- **Option A:** If the energy difference were zero, the two transitions would produce identical wavelengths and appear as a single line.
- **Option C:** Light intensity determines spectral line brightness, not the wavelength interval separating distinct transitions.
- **Option D:** Closely spaced spectral lines are standard features of atomic spectra (e.g., fine-structure doublet splitting) and do not imply nuclear or atomic instability.

Question #139 **Key: (C)**PHYSICS
05. Waves

When two identical waves arrive in phase at same point in a region at the same time the resulta...

CORE CONCEPT & DERIVATION

The principle of superposition states that when two or more propagating waves overlap at a spatial point, the net instantaneous displacement equals the algebraic sum of the individual wave displacements.

Formula / Rule / Reaction:

$$y_{\text{net}} = y_1 + y_2 \quad (\text{For identical in-phase waves: } y_1 = y_2 = y \implies y_{\text{net}} = 2y)$$

Solution:

- Constructive interference occurs when two identical waves meet with zero phase difference (in phase).
- The crests and troughs align simultaneously, causing the individual displacements to add constructively to yield twice the amplitude of a single wave.

Why other options are incorrect:

- **Option A:** Displacement of a single wave represents an unperturbed solitary wave without interference.
- **Option B:** The difference of displacements occurs during completely destructive interference when waves meet 180° out of phase.
- **Option D:** Displacements add linearly in linear media; they do not multiply.

Question #140 **Key: (B)**PHYSICS
13. Electronics

High slope of Ohm's law graph (V vs I) means:

CORE CONCEPT & DERIVATION

In a standard voltage versus current (V-I) graph for an ohmic conductor, potential difference is plotted on the vertical axis and current on the horizontal axis, making the slope equal to resistance.

Formula / Rule / Reaction:

$$\text{Slope} = \frac{\Delta V}{\Delta I} = R$$

Solution:

- According to Ohm's law, $V = IR$.
- In a V versus I coordinate system, the gradient of the straight-line plot is $\Delta V / \Delta I$, which equals the electrical resistance R .
- A steeper, higher slope indicates that a larger voltage is required to drive a unit of current, signifying high resistance.

Why other options are incorrect:

- **Option A:** Low resistance produces a gentle, low slope on a V-I graph (or a high slope only if plotted as I vs V).
- **Option C:** An open circuit produces an infinite vertical line where current is zero regardless of voltage.
- **Option D:** Low current is a secondary circuit outcome, not the direct physical quantity defined by the slope.

Question #141 Key: (C)PHYSICS
08. Electrostatics

The electric potential at a point due to a point charge is 100 J/C. If a test charge of magnitude...

CORE CONCEPT & DERIVATION

Electric potential and electric field at a point in space are determined solely by the source charge and location, whereas electric potential energy depends directly on the magnitude of the placed test charge.

Formula / Rule / Reaction:

$$V = \frac{kQ}{r} = \text{constant}; \quad U = q_0 V \Rightarrow U \propto q_0$$

Solution:

- Electric potential $V = 100 \text{ J/C}$ is an intrinsic property of the electrostatic field established by the primary source charge.
- When the test charge q_0 is increased from 1 C to 2 C, the electric potential energy increases from $U_1 = (1 \text{ C})(100 \text{ J/C}) = 100 \text{ J}$ to $U_2 = (2 \text{ C})(100 \text{ J/C}) = 200 \text{ J}$.

Why other options are incorrect:

- Option A:** The electric field $E = kQ/r^2$ depends only on the source charge and coordinate distance, remaining unchanged.
- Option B:** The electric potential is work per unit charge (100 J/C) and does not change with test charge magnitude.
- Option D:** Electrostatic test charge substitutions do not alter ambient thermodynamic temperature.

Question #142 Key: (D)PHYSICS
12. Alternating Current

The waves among the following which require a material medium for their propagation are:

CORE CONCEPT & DERIVATION

Mechanical waves require an elastic material medium to propagate via particle oscillations, whereas electromagnetic waves propagate through vacuum via oscillating electric and magnetic fields.

Formula / Rule / Reaction:

$$\text{Sound Speed: } v = \sqrt{\frac{E}{\rho}} \quad (\text{Medium required; cannot propagate in vacuum})$$

Solution:

- Infrasonic waves are acoustic (sound) waves with frequencies below 20 Hz.
- Because sound is a longitudinal mechanical wave requiring particle-to-particle collisions to transmit compressions and rarefactions, it cannot propagate without a material medium.

Why other options are incorrect:

- Option A:** Gamma rays are high-energy electromagnetic waves that travel freely through the vacuum of space.
- Option B:** X-rays are electromagnetic waves capable of propagating without a physical medium.
- Option C:** Infrared waves are electromagnetic radiation and do not require matter to propagate.

Question #143 Key: (D)PHYSICS
02. Force & Motion

Unequal-changes occurring in velocity of a body is called:

CORE CONCEPT & DERIVATION

When a moving body experiences unequal changes in velocity over equal intervals of time, its acceleration is non-constant, defining variable (non-uniform) acceleration.

Formula / Rule / Reaction:

$$a(t) = \frac{dv}{dt} \neq \text{constant} \Rightarrow \text{Variable acceleration}$$

Solution:

- Acceleration is defined as the rate of change of velocity with respect to time: $a = \Delta v / \Delta t$.
- If Δv is not constant across successive identical time intervals Δt , the acceleration varies with time, producing variable acceleration.

Why other options are incorrect:

- Option A:** Uniform acceleration requires equal changes in velocity in equal intervals of time.
- Option B:** Uniform velocity means velocity remains constant with zero acceleration.
- Option C:** Instantaneous acceleration is the acceleration evaluated at a specific moment in time ($\lim_{\Delta t \rightarrow 0} \Delta v / \Delta t$).

Question #144 Key: (C)PHYSICS
09. Current Electricity

What will potential difference, if a wire has resistance of 10 ohms and current 2A flow through...

CORE CONCEPT & DERIVATION

According to Ohm's law, the potential difference across a conductor is the product of the electric current flowing through it and its electrical resistance.

Formula / Rule / Reaction:

$$V = I \cdot R$$

Solution:

- Given: Resistance $R = 10 \Omega$ and current $I = 2 \text{ A}$.
- Substitute the values into Ohm's law: $V = 2 \text{ A} \times 10 \Omega = 20 \text{ V}$.
- Note on board erratum:* Some unofficial answer keys mistakenly marked Option B (10 V); Option C (20 V) is the mathematically sound solution.

Why other options are incorrect:

- Option A:** 5 V results from dividing resistance by current ($10/2$), violating Ohm's law.
- Option B:** 10 V represents a calculation error where current is assumed to be 1 A.
- Option D:** 40 V assumes a current of 4 A.

Question #145 Key: (B)PHYSICS
14. Dawn of Modern Physics

According to the particle model of light, a photon is:

CORE CONCEPT & DERIVATION

In quantum electrodynamics and Einstein's particle model, light consists of localized discrete quanta called photons, each carrying energy $E = h\nu$, zero rest mass, and zero electric charge.

Formula / Rule / Reaction:

$$E = h\nu, \quad p = \frac{h}{\lambda}, \quad m_0 = 0, \quad q = 0, \quad v = c$$

Solution:

- Photons are fundamental gauge bosons mediating the electromagnetic force.
- They possess zero invariant rest mass ($m_0 = 0$), carry no electric charge ($q = 0$), and travel at the speed of light in vacuum ($c \approx 3 \times 10^8$ m/s).

Why other options are incorrect:

- Option A:** Photons carry neither rest mass nor electric charge.
- Option C:** A continuous wave describes classical Maxwellian wave theory, contrasting with the discrete packet model of quantum theory.
- Option D:** Photons travel at the speed of light in vacuum; they cannot travel slower than c in free space.

Question #146 Key: (A)PHYSICS
13. Electronics

The current in forward biased PN junction is mainly due to:

CORE CONCEPT & DERIVATION

Applying forward bias reduces the potential barrier across a PN junction, allowing majority charge carriers to diffuse across the depletion region.

Formula / Rule / Reaction:

$$I = I_0 \left(e^{eV/k_B T} - 1 \right) \quad (\text{Forward current dominated by majority carrier diffusion})$$

Solution:

- Under forward bias, the positive terminal connects to the p-type material and the negative terminal to the n-type material, opposing the built-in potential.
- This lowered barrier allows electrons in the n-region and holes in the p-region (majority carriers) to diffuse across the junction, generating large forward current.

Why other options are incorrect:

- Option B:** Minority carriers dominate the reverse saturation current under reverse bias conditions.
- Option C:** Leakage current is the tiny reverse current caused by thermally generated minority carriers.
- Option D:** Thermionic emission is the thermal ejection of electrons from a heated cathode surface into vacuum, not junction diffusion.

Question #147 Key: (B)PHYSICS
05. Waves

Stationary waves are formed in a stretched string of 2m length, such that two vibrating loops are...

CORE CONCEPT & DERIVATION

In a standing wave on a string fixed at both ends, the length of one vibrating loop equals half a wavelength, which represents the distance between two consecutive nodes.

Formula / Rule / Reaction:

$$L = n \left(\frac{\lambda}{2} \right); \quad d_{\text{node-node}} = \frac{\lambda}{2} = \frac{L}{n}$$

Solution:

- Given: String length $L = 2$ m and number of vibrating loops $n = 2$.
- The wavelength is $\lambda = L = 2$ m.
- The distance between two consecutive nodes equals the length of one loop: $d = \lambda/2 = 2/2 = 1$ m.

Why other options are incorrect:

- Option A:** 0.5 m is the distance between adjacent nodes in a four-loop mode ($n = 4$).
- Option C:** 2 m is the total string length and the full wavelength of the second harmonic.
- Option D:** 3 m exceeds the length of the string.

Question #148 Key: (A)PHYSICS
02. Force & MotionA football is kicked with a speed of 20 m/s at an angle of 30° With the horizontal, the maximum...**CORE CONCEPT & DERIVATION**

The maximum vertical height reached by a projectile depends on the square of the vertical component of its initial velocity and the acceleration due to gravity.

Formula / Rule / Reaction:

$$H_{\text{max}} = \frac{v_0^2 \sin^2 \theta}{2g}$$

Solution:

- Given: Initial speed $v_0 = 20$ m/s, launch angle $\theta = 30^\circ$, and $g \approx 10$ m/s².
- Vertical velocity component: $v_{0y} = v_0 \sin(30^\circ) = 20 \times 0.5 = 10$ m/s.
- Maximum height: $H_{\text{max}} = \frac{(10)^2}{2 \times 10} = \frac{100}{20} = 5$ m.

Why other options are incorrect:

- Option B:** 10 m would be attained if the ball were launched vertically at 30° without squaring the sine factor.
- Option C:** 15 m is an overestimation that fails to resolve initial velocity into its orthogonal components.
- Option D:** 20 m would require launching the projectile straight up at 90° .

Question #149 Key: (A)PHYSICS
09. Current Electricity

A high internal resistance battery is not suitable for heavy loads due to:

CORE CONCEPT & DERIVATION

When a heavy load draws large electric current from a battery, internal resistance causes an internal potential drop, reducing the terminal voltage delivered to the load.

Formula / Rule / Reaction:

$$V_t = E - Ir \quad (\text{where } Ir = \text{internal voltage drop})$$

Solution:

- A heavy electrical load has low load resistance (R_L) and demands a large current I .
- If the internal resistance r of the battery is high, the internal voltage drop Ir becomes large, leaving insufficient terminal potential difference V_t to operate the load.

Why other options are incorrect:

- Option B:** Terminal voltage drops significantly under heavy load, rather than remaining high.
- Option C:** Electromotive force (EMF) is a finite chemical property of the cell, never infinite.
- Option D:** Current varies inversely with total circuit resistance and does not remain constant.

Question #150 Key: (C)PHYSICS
08. Electrostatics

Two equal charges experience a certain force when placed in vacuum. When the charges are placed...

CORE CONCEPT & DERIVATION

The electrostatic Coulomb force between two charges is reduced in a dielectric medium by a factor equal to the relative permittivity (dielectric constant) of the medium.

Formula / Rule / Reaction:

$$F_{\text{med}} = \frac{F_{\text{vac}}}{\epsilon_r} \implies \epsilon_r = \frac{F_{\text{vac}}}{F_{\text{med}}}$$

Solution:

- Given: $F_{\text{med}} = \frac{1}{4} F_{\text{vac}}$.
- Rearranging for the dielectric constant: $\epsilon_r = \frac{F_{\text{vac}}}{F_{\text{med}}} = 4$.
- The dielectric constant of the medium is 4.

Why other options are incorrect:

- Option A:** 0.25 is the reciprocal of the dielectric constant, representing $1/\epsilon_r$.
- Option B:** A dielectric constant of 2 would reduce the force to half, not one-fourth.
- Option D:** 16 squares the dielectric constant value.

Question #151 Key: (B)PHYSICS
08. Electrostatics

If a test charge of magnitude $2C$ experience forces of $100N$ and $200N$ at two points A and B in ...

CORE CONCEPT & DERIVATION

The electric field intensity at any point is defined as the electrostatic force experienced per unit positive test charge placed at that location.

Formula / Rule / Reaction:

$$E = \frac{F}{q} \implies \frac{E_A}{E_B} = \frac{F_A/q}{F_B/q} = \frac{F_A}{F_B}$$

Solution:

- Because the identical test charge ($q = 2C$) is used at both locations, the electric field strength is directly proportional to the measured force.
- The ratio of field intensities is: $E_A : E_B = 100N : 200N = 1 : 2$.

Why other options are incorrect:

- Option A:** 1:1 implies equal forces were measured at points A and B.
- Option C:** 1:4 incorrectly squares the force ratio.
- Option D:** 4:1 inverts and squares the ratio of electric field strengths.

Question #152 Key: (B)PHYSICS
02. Force & Motion

A body of mass 2 kg moving with velocity 3 m/s collides with a body of mass 1 kg at rest. If th...

CORE CONCEPT & DERIVATION

In a perfectly inelastic collision where interacting bodies stick together, total linear momentum is conserved in the absence of external net forces.

Formula / Rule / Reaction:

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) v_f \implies v_f = \frac{m_1 v_1 + m_2 v_2}{m_1 + m_2}$$

Solution:

- Given: $m_1 = 2\text{ kg}$, $v_1 = 3\text{ m/s}$, $m_2 = 1\text{ kg}$, and $v_2 = 0\text{ m/s}$.
- Total initial momentum: $P_i = (2\text{ kg})(3\text{ m/s}) + (1\text{ kg})(0) = 6\text{ kg} \cdot \text{m/s}$.
- Combined mass after collision: $m_1 + m_2 = 2 + 1 = 3\text{ kg}$.
- Final common velocity: $v_f = \frac{6\text{ kg} \cdot \text{m/s}}{3\text{ kg}} = 2\text{ m/s}$.

Why other options are incorrect:

- Option A:** 1 m/s results from dividing initial momentum by an incorrect mass of 6 kg .
- Option C:** 3 m/s would mean the moving mass transferred no momentum to the stationary body.
- Option D:** 4 m/s violates the principle of conservation of linear momentum.

Question #153 Key: (D)PHYSICS
02. Force & Motion

Two balls thrown with equal speeds but at different angles cover equal horizontal distance. If ...

CORE CONCEPT & DERIVATION

For a projectile launched across level ground at a given initial speed, complementary angles of projection (angles that sum to 90°) produce identical horizontal ranges.

Formula / Rule / Reaction:

$$R = \frac{v_0^2 \sin(2\theta)}{g}; \quad \sin(2(90^\circ - \theta)) = \sin(180^\circ - 2\theta) = \sin(2\theta) \implies \theta_2 = 90^\circ - \theta_1$$

Solution:

- Given launch angle: $\theta_1 = 40^\circ$.
- The complementary angle yielding the exact same range is: $\theta_2 = 90^\circ - 40^\circ = 50^\circ$.

Why other options are incorrect:

- Option A:** 20° has a complement of 70° , yielding a shorter range than at 40° .
- Option B:** 30° is complementary to 60° , not 40° .
- Option C:** 45° is the unique angle that maximizes horizontal projectile range.

Question #154 Key: (B)PHYSICS
03. Work & Energy

The work done on a body is stored in it in the form of:

CORE CONCEPT & DERIVATION

By the work-energy theorem, mechanical work performed by net external forces on a system results in an equivalent change and storage of mechanical energy.

Formula / Rule / Reaction:

$$W = \Delta E = \Delta K + \Delta U$$

Solution:

- When work is done against conservative forces (such as gravitational or elastic forces), it is stored as potential energy.
- When work accelerates an object, it is converted into kinetic energy, confirming that work done is stored in the form of energy.

Why other options are incorrect:

- Option A:** Power is the time rate of doing work ($P = dW/dt$), not a stored physical quantity.
- Option C:** Momentum is the product of mass and velocity ($p = mv$), not equivalent to accumulated work.
- Option D:** Impulse is the integral of force over time ($J = \int F dt$), producing a change in linear momentum.

Question #155 Key: (A)PHYSICS
05. Waves

If 20 waves pass a point in 2 seconds and with a speed of 5 m/s, then the wavelength of wave is:

CORE CONCEPT & DERIVATION

Wavelength is the ratio of wave propagation speed to frequency, where frequency is the number of complete wave cycles passing a fixed point per unit time.

Formula / Rule / Reaction:

$$f = \frac{N}{t}; \quad v = f\lambda \implies \lambda = \frac{v}{f}$$

Solution:

- Calculate wave frequency: $f = \frac{20 \text{ waves}}{2 \text{ seconds}} = 10 \text{ Hz}$.
- Given wave speed $v = 5 \text{ m/s}$, solve for wavelength: $\lambda = \frac{5 \text{ m/s}}{10 \text{ Hz}} = 0.5 \text{ m}$.

Why other options are incorrect:

- Option B:** 1 m would result if the wave speed were 10 m/s.
- Option C:** 1.5 m does not satisfy the wave speed equation $v = f\lambda$.
- Option D:** 2 m inverts the frequency calculation (10/5).

Question #156 Key: (B)PHYSICS
08. Electrostatics

The unit of RC in case of charging a capacitor is:

CORE CONCEPT & DERIVATION

The product of electrical resistance R and capacitance C defines the capacitive time constant τ of a circuit, possessing the physical dimension of time.

Formula / Rule / Reaction:

$$[\tau] = [R][C] = \left(\frac{\text{Volt}}{\text{Ampere}}\right) \times \left(\frac{\text{Coulomb}}{\text{Volt}}\right) = \frac{\text{Coulomb}}{\text{Coulomb/Second}} = \text{Seconds}$$

Solution:

- In transient RC charging circuits, the voltage across the capacitor rises according to $V(t) = V_0(1 - e^{-t/RC})$.
- Because the exponent $-t/RC$ must be dimensionless, the product RC has the unit of seconds.

Why other options are incorrect:

- Option A:** The Farad is the unit of capacitance C .
- Option C:** The Ohm is the unit of resistance R .
- Option D:** The Volt is the unit of electric potential difference.

Question #157 Key: (C)PHYSICS
05. Waves

A longitudinal wave has a frequency of 500 Hz and wavelength of 0.6 m, its speed is:

CORE CONCEPT & DERIVATION

The propagation velocity of any wave is equal to the product of its temporal frequency and spatial wavelength.

Formula / Rule / Reaction:

$$v = f \cdot \lambda$$

Solution:

- Given: Frequency $f = 500$ Hz and wavelength $\lambda = 0.6$ m.
- Calculate speed: $v = 500 \text{ s}^{-1} \times 0.6 \text{ m} = 300 \text{ m/s}$.

Why other options are incorrect:

- Option A:** 30 m/s misplaces the decimal point during multiplication.
- Option B:** 83 m/s results from dividing frequency by wavelength.
- Option D:** 1200 m/s results from multiplying by an incorrect scalar factor.

Question #158 Key: (B)PHYSICS
01. Vectors & Equilibrium

The true statement about angular displacement is:

CORE CONCEPT & DERIVATION

Finite angular displacements do not obey the commutative law of vector addition, whereas infinitesimal (small) angular rotations commute and are treated as true axial vectors.

Formula / Rule / Reaction:

$$d\vec{\theta}_1 + d\vec{\theta}_2 = d\vec{\theta}_2 + d\vec{\theta}_1 \quad (\text{Commutative for infinitesimal rotations})$$

Solution:

- Large, finite angular rotations cannot be represented as vectors because the final orientation depends on the order of rotation ($\theta_1 + \theta_2 \neq \theta_2 + \theta_1$).
- Infinitesimal angular displacements commute under addition, allowing them to be treated as vectors whose direction is given by the right-hand rule.

Why other options are incorrect:

- Option A:** Angular displacement can decrease, oscillate, or reverse sign depending on rotation direction.
- Option C:** Small angular displacements behave as axial vectors, not scalars.
- Option D:** Angular displacement is measured in dimensionless radians or degrees, not meters.

Question #159 Key: (D)PHYSICS
04. Rotational & Circular Motion

π radians are equivalent to:

CORE CONCEPT & DERIVATION

A full circular revolution traverses an angle of 360° , which corresponds to 2π radians; therefore, π radians is equal to 180° .

Formula / Rule / Reaction:

$$\theta_{\text{deg}} = \theta_{\text{rad}} \times \left(\frac{180^\circ}{\pi}\right) \implies \pi \times \left(\frac{180^\circ}{\pi}\right) = 180^\circ$$

Solution:

- By definition, one complete rotation around a circle subtends 2π radians at the center, equivalent to 360° .
- Dividing both sides by 2 yields π radians = 180° .

Why other options are incorrect:

- Option A:** 30° corresponds to $\pi/6$ radians.
- Option B:** 270° corresponds to $3\pi/2$ radians.
- Option C:** 90° corresponds to $\pi/2$ radians.

Question #160 Key: (B)PHYSICS
02. Force & Motion

A person moves 600 m towards north then 300 m towards south. Its displacement to distance ratio...

CORE CONCEPT & DERIVATION

Distance is the total scalar path length traversed, whereas displacement is the net vector change in position from initial to final point.

Formula / Rule / Reaction:

$$\text{Distance} = d_1 + d_2; \quad \text{Displacement} = |\vec{d}_1 + \vec{d}_2|$$

Solution:

- Total path distance: $600 \text{ m} + 300 \text{ m} = 900 \text{ m}$.
- Net displacement: Taking north as positive, $\Delta x = +600 \text{ m} - 300 \text{ m} = +300 \text{ m}$ (north).
- Displacement to distance ratio: $300 \text{ m} : 900 \text{ m} = 1 : 3$.
- Note on board erratum:* Some preliminary keys incorrectly printed 1:2; the mathematically sound ratio is 1:3.

Why other options are incorrect:

- Option A:** 1:2 is a ratio error that miscalculates net displacement or distance.
- Option C:** 2:1 incorrectly states that displacement exceeds path distance.
- Option D:** 3:1 inverts the ratio, representing distance to displacement.

Question #161 Key: (A)PHYSICS
05. Waves

In a stationary wave the point that undergoes zero acceleration is:

CORE CONCEPT & DERIVATION

In a standing wave, a node is a point of permanent destructive interference where displacement remains zero at all times; consequently, its velocity and acceleration are identically zero.

Formula / Rule / Reaction:

$$y(x, t) = 2A \sin(kx) \cos(\omega t); \quad a(x, t) = -\omega^2 y(x, t) \implies \text{At a node } (y = 0) : a = 0$$

Solution:

- In simple harmonic motion, particle acceleration is directly proportional to displacement: $a = -\omega^2 y$.
- At nodal points, destructive interference ensures that the medium displacement y is zero at all times, meaning the acceleration is permanently zero.

Why other options are incorrect:

- Option B:** Antinodes experience maximum displacement and therefore undergo maximum acceleration.
- Option C:** Points between nodes and antinodes oscillate with intermediate amplitudes and experience non-zero acceleration.
- Option D:** Most points along a standing wave oscillate with non-zero acceleration, except nodes.

Question #162 Key: (C)PHYSICS
05. Waves

If the speed of sound is measured at sea level and at the top of a mountain, both at the same t...

CORE CONCEPT & DERIVATION

The speed of sound in an ideal gas depends solely on the adiabatic index, the gas constant, and the absolute temperature, remaining independent of pressure and density changes at constant temperature.

Formula / Rule / Reaction:

$$v = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{M}}$$

Solution:

- According to Boyle's law, at constant temperature, pressure is directly proportional to density ($P/\rho = \text{constant}$).
- Although air pressure and density are lower at the top of a mountain, their ratio P/ρ remains constant at equal temperatures.
- Therefore, the speed of sound depends only on temperature and is identical at both locations.

Why other options are incorrect:

- Option A:** Sound speed does not increase with higher pressure if temperature is held constant.
- Option B:** Lower air density at mountain altitudes does not increase sound velocity because pressure decreases proportionally.
- Option D:** Denser air does not increase sound speed at constant temperature because the increased inertia offsets the pressure change.

Question #163 Key: (B)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

The book was written by Rashid Khan. Identify the correct usage of voice.

CORE CONCEPT & DERIVATION

In converting a passive voice sentence in the simple past tense ('was written') to active voice, the auxiliary verb is omitted and the main verb takes its simple past form ('wrote').

Formula / Rule / Reaction:

Passive: Object + was/were + V_3 + by Subject $\implies$ Active: Subject + V_2 (past simple) + Object

Solution:

- The sentence 'The book was written by Rashid Khan' uses the simple past passive form ('was written').
- In active voice, the agent ('Rashid Khan') becomes the grammatical subject, taking the simple past tense verb 'wrote' followed by the direct object 'the book'.

Why other options are incorrect:

- Option A:** 'Writes' is simple present tense, changing the temporal meaning of the sentence.
- Option C:** 'Written' is a past participle that cannot function as a standalone finite verb without an auxiliary.
- Option D:** 'Has write' is grammatically incorrect; the present perfect requires the past participle 'written'.

Question #164 Key: (B)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Identify the example of complex sentence.

CORE CONCEPT & DERIVATION

A complex sentence consists of exactly one independent clause and at least one dependent (subordinate) clause joined by a subordinating conjunction or relative pronoun.

Formula / Rule / Reaction:

Complex Sentence = Independent Clause + Dependent Subordinate Clause

Solution:

- In 'Life is what we make it', the main independent clause is 'Life is [predicate noun]' and the dependent clause is the noun clause 'what we make it', functioning as the predicative complement.
- This structure satisfies the grammatical definition of a complex sentence.

Why other options are incorrect:

- Option A:** 'I both thanked him and rewarded him' is a simple sentence containing a compound predicate.
- Option C:** 'He owed his success to his father' is a simple sentence containing one independent clause.
- Option D:** 'Jumping up, he ran away' is a simple sentence modified by a participial phrase ('Jumping up').

Question #165 **Key: (A)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Pick out the sentence which illustrates the use of infinitive.

CORE CONCEPT & DERIVATION

An infinitive is the base form of a verb typically preceded by the particle 'to' ('to + verb'), functioning as a noun, adjective, or adverb.

Formula / Rule / Reaction:

Full Infinitive = 'to' + base verb (V_1)

Solution:

- The verb 'refuse' takes a full infinitive complement.
- In 'He refused to obey the orders', 'to obey' functions as the full infinitive acting as the direct object of 'refused'.

Why other options are incorrect:

- **Option B:** 'Obeying' is a gerund; the verb 'refuse' does not take a gerund complement in standard English.
- **Option C:** Omitting 'to' creates an ungrammatical bare infinitive after 'refuse'.
- **Option D:** 'Obeyed' is a past tense form that cannot follow the finite verb 'refused'.

Question #166 **Key: (B)**ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

What is the effect of using different shades of meaning in satire?

CORE CONCEPT & DERIVATION

Satire utilizes nuanced diction, irony, and lexical connotations to expose societal follies, vices, and incongruities through deliberate double meanings.

Formula / Rule / Reaction:

Rhetorical function of satire: Juxtaposition of connotation → Exposure of absurdity and irony.

Solution:

- Satirists select words with subtle nuances and distinct shades of meaning to contrast superficial appearance with reality.
- This lexical selection accentuates the irony and absurdity of the subject being critiqued.

Why other options are incorrect:

- **Option A:** Satire uses humor, irony, and ridicule rather than attempting to maintain a solemn, serious tone.
- **Option C:** Effective satire clarifies critique through wit rather than creating pointless reader confusion.
- **Option D:** Adding linguistic complexity is merely stylistic and not the primary communicative purpose of satire.

Question #167 **Key: (A)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

People approach the situation differently depending on who they are. The word 'approach' in thi...

CORE CONCEPT & DERIVATION

In context, the verb 'approach' means to deal with, address, or relate to a task, problem, or situation from a particular perspective.

Formula / Rule / Reaction:

Contextual Lexical Semantics: 'Approach a situation' = deal with / address / relate to.

Solution:

- The sentence refers to how diverse individuals engage with and respond to circumstances based on their personal traits.
- Among the choices, 'relate' (to interact with or respond to) best captures the contextual meaning of approaching a situation.

Why other options are incorrect:

- **Option B:** 'Coordinate' means to harmonize or organize disparate elements into a unified whole.
- **Option C:** 'Comprehend' means to mentally understand or grasp, omitting the active behavioral response implied by 'approach'.
- **Option D:** 'Verify' means to authenticate, confirm, or prove true.

Question #168 **Key: (C)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

The team won the match, ... they broke the school record.

CORE CONCEPT & DERIVATION

Additive transitions introduce additional supporting information that reinforces or builds upon an established positive clause.

Formula / Rule / Reaction:

Clause 1 (Achievement) + Additive Conjunctive Adverb (Furthermore) + Clause 2 (Addition)

Solution:

- The sentence connects two complementary achievements: winning the match and breaking the school record.
- 'Furthermore' is an additive transitional adverb that appropriately links and amplifies the second achievement.

Why other options are incorrect:

- **Option A:** 'Similarly' denotes comparison between two analogous situations, rather than adding a supplementary accomplishment.
- **Option B:** 'Nevertheless' introduces an adversative concession or unexpected contrast.
- **Option D:** 'Instead' indicates replacement or mutual exclusion between alternatives.

Question #169 **Key: (A)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Identify the sentence with no spelling errors.

CORE CONCEPT & DERIVATION

Standard English orthography requires precise letter patterns: 'homework' (compound noun) and 'assignments' (double 's', single 'g', 'n-m-e-n-t').

Formula / Rule / Reaction:

Correct orthography: 'homework' + 'assignments'

Solution:

- Option A correctly spells 'completes', 'homework', and 'assignments', while maintaining subject-verb agreement.
- All other options contain typographical or grammatical errors.

Why other options are incorrect:

- Option B:** Contains the misspelling 'homwork' and lacks singular agreement on 'complete'.
- Option C:** Contains the misspelling 'asignments' (missing second 's').
- Option D:** Contains the misspelling 'assigments' (missing 'n').

Question #170 **Key: (C)**ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Traveling in hot, dusty terrain gives me no pleasure. The underlined part of the sentence is:

CORE CONCEPT & DERIVATION

A gerund phrase consists of a gerund and its associated modifiers and objects, functioning collectively as a noun phrase to serve as the subject of a clause.

Formula / Rule / Reaction:

[Traveling in hot, dusty terrain] = Subject (Noun Phrase / Gerund Phrase)

Solution:

- The phrase 'Traveling in hot, dusty terrain' occupies the subject position of the finite verb 'gives'.
- Because it functions syntactically as the subject of the sentence, it is classified as a noun phrase.

Why other options are incorrect:

- Option A:** Adverb phrases modify verbs, adjectives, or other adverbs, rather than serving as grammatical subjects.
- Option B:** While 'in hot, dusty terrain' is a prepositional phrase, the full subject phrase is headed by the gerund 'traveling'.
- Option D:** An infinitive phrase must be headed by 'to + base verb', which is absent here.

Question #171 **Key: (B)**ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

What does "I've told you a million times" mean?

CORE CONCEPT & DERIVATION

Hyperbole is a figure of speech that uses intentional exaggeration not meant to be taken literally, employed here to convey strong emotion such as annoyance or frustration.

Formula / Rule / Reaction:

Figurative Language: Hyperbolic exaggeration → Emotional emphasis of impatience.

Solution:

- The expression 'a million times' is a common hyperbolic idiom.
- It emphasizes that the speaker has repeated an instruction many times, conveying frustration or impatience rather than stating a literal numerical tally.

Why other options are incorrect:

- Option A:** The phrase is figurative hyperbole, not an exact mathematical count.
- Option C:** The idiom is used to reinforce a point clearly, not to confuse the listener.
- Option D:** The expression reflects standard conversational emphasis, not foolishness.

Question #172 **Key: (C)**LOGICAL REASONING
03. Courses of Action & Decision-Making

An outbreak of a corona disease is reported in the city. What should be the first course of act...

CORE CONCEPT & DERIVATION

In public health crisis intervention and logical decision-making, the immediate containment of a contagious viral pathogen requires rapid containment and quarantine measures to break transmission chains.

Formula / Rule / Reaction:

Epidemic Containment Sequence: Immediate Quarantine and Isolation → Public Advisories → Vaccination and Research.

Solution:

- An infectious respiratory outbreak presents an immediate risk of geometric spread through contact.
- Immediate enforcement of quarantine and isolation measures halts the transmission vector, preventing the collapse of regional medical infrastructure while secondary measures are organized.

Why other options are incorrect:

- Option A:** Developing and manufacturing a vaccine requires months or years, offering no immediate containment.
- Option B:** Academic research is a long-term strategy that does not stop active viral transmission.
- Option D:** Public communication is essential, but must accompany direct containment measures to halt spread.

Question #173 **Key: (B)**LOGICAL REASONING
07. Number Series & Numerical Progressions

Find the next number: 5, 11, 23, 47, 95, ____?

CORE CONCEPT & DERIVATION

In a recursive arithmetic sequence, each successive term is generated by multiplying the preceding term by a constant and adding a fixed integer, or by adding successive powers of 2 multiplied by an initial difference.

Formula / Rule / Reaction:

$$T_n = 2 \cdot T_{n-1} + 1$$

Solution:

- $5 \times 2 + 1 = 11$
- $11 \times 2 + 1 = 23$
- $23 \times 2 + 1 = 47$
- $47 \times 2 + 1 = 95$
- Next term: $95 \times 2 + 1 = 190 + 1 = 191$.

Why other options are incorrect:

- **Option A:** 190 doubles 95 without adding the required constant 1.
- **Option C:** 192 adds 2 instead of 1.
- **Option D:** 193 adds 3 instead of 1.

Question #174 **Key: (B)**LOGICAL REASONING
07. Number Series & Numerical Progressions

Which number comes in the missing place? 1, 3, 7, 15, 31, ____.

CORE CONCEPT & DERIVATION

In this numerical sequence, each term is obtained by doubling the preceding term and adding 1, representing numbers of the form $2^n - 1$.

Formula / Rule / Reaction:

$$T_n = 2^n - 1 \quad \text{or} \quad T_n = 2 \cdot T_{n-1} + 1$$

Solution:

- $T_1 = 2^1 - 1 = 1$
- $T_2 = 2^2 - 1 = 3$
- $T_3 = 2^3 - 1 = 7$
- $T_4 = 2^4 - 1 = 15$
- $T_5 = 2^5 - 1 = 31$
- Next term: $T_6 = 2^6 - 1 = 64 - 1 = 63$.

Why other options are incorrect:

- **Option A:** 61 fails to follow the $2^n - 1$ progression.
- **Option C:** 65 corresponds to $2^6 + 1$, adding 1 instead of subtracting 1.
- **Option D:** 67 deviates from the recursive rule.

Question #175 **Key: (C)**LOGICAL REASONING
11. Set Theory, Integer Bounds & Arithmetic

Every alphabet in the word "SURGEON" represent a fixed numerical value and the numbers when add...

CORE CONCEPT & DERIVATION

The commutative property of addition states that the sum of a finite set of real numbers remains unchanged regardless of the order in which they are added.

Formula / Rule / Reaction:

$$\sum_{i=1}^n x_i = x_{\pi(1)} + x_{\pi(2)} + \cdots + x_{\pi(n)}$$

Solution:

- The word 'SURGEON' consists of the distinct letters: S, U, R, G, E, O, N.
- The word 'EORGNSU' is an exact anagram containing the identical seven letters: E, O, R, G, N, S, U.
- Because letter values are fixed and addition is commutative, the sum of their numerical values remains 99.

Why other options are incorrect:

- **Option A:** 102 incorrectly adds values to an identical set of letters.
- **Option B:** 78 assumes letters were omitted from the set.
- **Option D:** 56 incorrectly reduces the sum of the original letters.

Question #176 **Key: (D)**LOGICAL REASONING
04. Argument Evaluation & Ethics

What is the primary difference between hypothesis and a theory?

CORE CONCEPT & DERIVATION

A hypothesis is a preliminary, testable proposition formulated to explain an observation, whereas a scientific theory is an empirically validated framework supported by experimental evidence.

Formula / Rule / Reaction:

$$\text{Observation} \rightarrow \text{Hypothesis (tentative)} \xrightarrow{\text{Rigorous testing}} \text{Theory (well-substantiated)}$$

Solution:

- A hypothesis is an initial, tentative explanation that can be tested through experimentation and falsification.
- A theory is a broad, well-substantiated explanation supported by extensive empirical data and independent experimental confirmation.

Why other options are incorrect:

- **Option A:** A hypothesis is never a proven fact, and a scientific theory is not unproven conjecture.
- **Option B:** A hypothesis is an explanatory proposal rather than merely a prediction.
- **Option C:** Both hypotheses and theories incorporate qualitative and quantitative components.

Question #177 Key: (A)LOGICAL REASONING
08. Letter Series & Coding-Decoding

ZX, WU, TR, QO.. What comes next?

CORE CONCEPT & DERIVATION

In alphabetical sequence puzzles, examine the step pattern of the first and second letters independently using their numerical positions in the alphabet.

Formula / Rule / Reaction:Position Series: $L_1 : 26 \xrightarrow{-3} 23 \xrightarrow{-3} 20 \xrightarrow{-3} 17 \xrightarrow{-3} 14$; $L_2 : 24 \xrightarrow{-3} 21 \xrightarrow{-3} 18 \xrightarrow{-3} 15 \xrightarrow{-3} 12$ **Solution:**

- First letters: Z (26), W (23), T (20), Q (17). Subtracting 3 gives position 14, which corresponds to N.
- Second letters: X (24), U (21), R (18), O (15). Subtracting 3 gives position 12, which corresponds to L.
- Combining both letters gives the next pair: NL.

Why other options are incorrect:

- **Option B:** LN inverts the letter order.
- **Option C:** NM subtracts 2 instead of 3 for the second letter.
- **Option D:** KH subtracts 6 from Q and 7 from O, skipping a step.

Question #178 Key: (C)LOGICAL REASONING
12. Linear Ranking, Ordering & Inequalities

In a row of students, a student is at 13th position from the left end and at 20th position from...

CORE CONCEPT & DERIVATION

When calculating total elements in a single ordered line from the positions of a single person counted from both ends, subtract one to avoid double-counting that person.

Formula / Rule / Reaction:

$$\text{Total} = \text{Position}_{\text{left}} + \text{Position}_{\text{right}} - 1$$

Solution:

- The student is 13th from the left and 20th from the right.
- Summing the two ranks: $13 + 20 = 33$.
- Because the student has been counted twice, subtract 1: $33 - 1 = 32$ total students.

Why other options are incorrect:

- **Option A:** 30 subtracts 3 students arbitrarily.
- **Option B:** 31 subtracts the student twice.
- **Option D:** 33 fails to subtract the overlapping count of the reference student.

Question #179 Key: (D)LOGICAL REASONING
12. Linear Ranking, Ordering & Inequalities

A is older than B but younger than F. C is younger than B but older than D. Who is the youngest...

CORE CONCEPT & DERIVATION

Linear order problems are solved by translating comparative statements into transitive inequality relationships.

Formula / Rule / Reaction:

$$\text{Premise 1: } F > A > B; \quad \text{Premise 2: } B > C > D \implies F > A > B > C > D$$

Solution:

- From 'A is older than B but younger than F': $F > A > B$.
- From 'C is younger than B but older than D': $B > C > D$.
- Combining the two inequalities gives the descending age order: $F > A > B > C > D$.
- D is the youngest member of the group.

Why other options are incorrect:

- **Option A:** A is older than B, C, and D.
- **Option B:** B is older than C and D.
- **Option C:** C is older than D.

Question #180 Key: (C)LOGICAL REASONING
04. Argument Evaluation & Ethics

A hiker climbed to a higher altitude, where he felt the air pressure was lower as compared to t...

CORE CONCEPT & DERIVATION

As barometric pressure falls at high altitudes, the partial pressure of oxygen decreases, causing arterial hypoxemia and the onset of acute altitude sickness.

Formula / Rule / Reaction:

$$\downarrow P_{\text{atm}} \implies \downarrow P_{\text{O}_2} = 0.21 \times P_{\text{atm}} \implies \text{Hypoxemia} \rightarrow \text{Acute Mountain Sickness}$$

Solution:

- Ascending to high altitude exposes the body to lower atmospheric pressure and reduced partial pressure of oxygen.
- Without prior acclimatization, the resulting drop in arterial oxygen saturation leads to altitude sickness, characterized by headaches, fatigue, dizziness, and dyspnea.

Why other options are incorrect:

- **Option A:** Hypoxia impairs aerobic ATP synthesis, causing fatigue rather than increased energy.
- **Option B:** Breathing difficulty (hyperventilation and dyspnea) is an immediate physiological response to high-altitude hypoxia.
- **Option D:** Acute drop in oxygen availability causes physical distress rather than enhanced freshness.