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UHS LAHORE

UHS Lahore MDCAT 2025 Official Paper

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

Official Admitting Board: University of Health Sciences Lahore Archive Code: BEAMBE-FLP-UHS-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

Kidneys perform their osmoregulatory role under the effect of Antidiuretic Hormone (ADH). Which type of urine is produced in this situation?

- (A) Hypotonic urine with decreased volume
- (B) Hypotonic urine with increased volume
- (C) Hypertonic urine with decreased volume
- (D) Hypertonic urine with increased volume

Q2. BIO

Which part of the brain controls the transition between sleeping and wakefulness?

- (A) Medulla oblongata
- (B) Cerebellum
- (C) Cerebrum
- (D) Pons

Q3. BIO

Which part of the brain contains central chemoreceptors that monitor CO_2 levels in the blood?

- (A) Pons
- (B) Midbrain
- (C) Hypothalamus
- (D) Medulla oblongata

Q4. BIO

Which component of a reflex arc connects the sensory neuron to the motor neuron within the spinal cord?

- (A) Receptor
- (B) Effector
- (C) Muscle fiber
- (D) Associative neuron

Q5. BIO

The 9 : 3 : 3 : 1 dihybrid phenotypic ratio of Mendel's law of independent assortment can be affected by:

- (A) Genetic drift
- (B) Small population
- (C) Gene linkage
- (D) Gene duplication

Q6. BIO

Which of the following is the best description of the process of crossing over during meiosis?

- (A) Duplication of chromosome
- (B) Exchange of genes between non-sister chromatids
- (C) Movement of chromosome to opposite poles
- (D) Separation of sister chromatids

Q7. BIO

Total number of linkage groups in a normal human is:

- (A) 02
- (B) 23
- (C) 46
- (D) 92

Q8. BIO

Nissl's granules are specialized structures in neurons formed by the modification of:

- (A) Golgi bodies & Smooth ER
- (B) Peroxisome & Mitochondria
- (C) Lysosome & Vacuole
- (D) Ribosome & Rough ER

Q9. BIO

What is the primary function of a centromere?

- (A) To protect the ends of chromosomes
- (B) To hold sister chromatids together
- (C) To carry genetic information
- (D) To initiate DNA replication

Q10. BIO

All of the following are functions of lysosomes EXCEPT:

- (A) Intracellular digestion
- (B) Removal of the waste
- (C) Autophagy
- (D) Lipid synthesis

Q11. BIO

The first consequence of lymphatic blockage in tissues is:

- (A) Deficiency of oxygen
- (B) Loss of nerve signals
- (C) Drop in blood pressure
- (D) Excess fluid accumulation in tissue

Q12. BIO

Which part of the brain acts as an auditory relay center and controls reflex movements of the eyes?

- (A) Forebrain
- (B) Cerebellum
- (C) Midbrain
- (D) Medulla oblongata

Q13. BIO

Which of the following is the correct pathway of nerve impulse?

- (A) Receptors → CNS → Effectors
- (B) Effectors → Receptors → CNS
- (C) CNS → Effectors → Receptors
- (D) Effectors → CNS → Receptors

Q14. BIO

The neurotransmitters are secreted by the neuron from:

- (A) Axon ends
- (B) Dendrite end
- (C) Nissl's granules
- (D) Cell body

Q15. BIO

Hippocampus plays an important role in the:

- (A) Formation of short-term memory
- (B) Formation of image on retina
- (C) Formation of long-term memory
- (D) Formation of emotions

Q16. BIO

Enzymes activity decreases at very low or high pH because:

- (A) Substrate concentration increases
- (B) Enzymes become denatured
- (C) Product formation increases
- (D) Temperature becomes constant

Q17. BIO

The complementary base pairing in DNA is important because it:

- (A) Maintains the tertiary structure of enzymes
- (B) Provides energy for all cell metabolism
- (C) Enables protein to fold properly
- (D) Allows DNA to act as a genetic blueprint during replication

Q18. BIO

A mature duplicated chromosome consists of:

- (A) Two identical double helical DNA molecules
- (B) Two different double helical DNA molecules
- (C) A double helical DNA molecule distributed in both chromatids
- (D) Histone chains wrapped around DNA core

Q19. BIO

The most primitive respiratory process occurring in a living cell is;

- (A) Lactic acid fermentation
- (B) Alcoholic fermentation
- (C) Glycolysis
- (D) Krebs's cycle

Q20. BIO

Receive, retain and nourish a fertilized ovum is the main function of:

- (A) Cervix
- (B) Uterus
- (C) Ovary
- (D) Oviduct

Q21. BIO

The primary function of larynx is:

- (A) Humidifying air
- (B) Filtering dust
- (C) Gaseous exchange
- (D) Voice production

Q22. BIO

During menstrual cycle, luteinizing hormone (LH) is secreted due to;

- (A) Decrease in Estrogen
- (B) Decrease in FSH
- (C) Increase in FSH
- (D) Environmental effect

Q23. BIO

Left and right cerebral hemispheres are connected with each other by:

- (A) Corpus luteum
- (B) Corpus callosum
- (C) A band of dendrites
- (D) Dorsal and ventral nerve roots

Q24. BIO

Which is the common feature between cardiac and smooth muscles?

- (A) Voluntary
- (B) Involuntary
- (C) Branched
- (D) Unbranched

Q25. BIO

The Joints which cause rotational movements are

- (A) Hinge
- (B) Ball and Socket
- (C) Cartilage
- (D) Sutures

Q26. BIO

Self-fertilization in plants through successive generations can lead to the development of:

- (A) Hybrid breeds of plants
- (B) Variations in coming generation
- (C) True breeding plants
- (D) Adaptation with their environment

Q27. BIO

Which part of the neuron typically receives incoming signals from other neurons?

- (A) Axon
- (B) Dendrites
- (C) Myelin sheath
- (D) Synaptic knob

Q28. BIO

Why thick filaments are unable to bind with thin filament in a relaxed muscle fiber?

- (A) Actin blocks the myosin binding site
- (B) Tropomyosin blocks the myosin binding site
- (C) Troponin blocks the myosin binding site
- (D) Tropomyosin blocks the troponin binding site

Q29. BIO

Which of the following best highlights the importance of proteins in immunity?

- (A) They act as receptors of pathogens
- (B) They are long term energy reserves
- (C) They act as antibodies
- (D) They act as mechanical barrier for pathogens

Q30. BIO

The secondary structure of proteins is stabilized by:

- (A) Ionic bonds
- (B) Hydrogen bonds
- (C) Disulfide bridges
- (D) Hydrophobic exclusion

Q31. BIO

The following is an example of a globular protein

- (A) Keratin
- (B) Collagen
- (C) Hemoglobin
- (D) Histone

Q32. BIO

The process of osmoregulation refers to:

- (A) The filtration of blood to remove metabolic waste
- (B) The regulation of solute and water movement between an organism and its environment
- (C) The creation of an osmotic gradient in the kidney medulla
- (D) The secretion of hormones that control blood plasma

Q33. BIO

A baby girl is born with hemophilia, which is an X-linked recessive disorder. What are the most likely genotypes of her parents?

- (A) The mother is a carrier and the father is normal
- (B) The mother is hemophiliac and the father is normal
- (C) The mother is a carrier and the father is hemophiliac
- (D) Both are normal

Q34. BIO

Identify the most appropriate function of chromosomes

- (A) Energy production and storage
- (B) Protein synthesis and regulation
- (C) Storage of genetic information
- (D) Lipid metabolism and transport

Q35. BIO

Enzymes belong to which class of biomolecules?

- (A) Carbohydrates
- (B) Lipids
- (C) Proteins
- (D) Nucleic acids

Q36. BIO

_____ arranges the DNA into the chromosomes in a eukaryotic cell

- (A) Hormones
- (B) Elastin
- (C) Histone
- (D) Nucleosome

Q37. BIO

The function of nucleolus is to make:

- (A) rDNA
- (B) Lysosomes
- (C) Ribosomes
- (D) Chromosomes

Q38. BIO

Which of the following blood vessels have lowest blood velocity with correct reason for low blood velocity?

- (A) Arteries: Due to thick walls
- (B) Capillaries: due to highest overall cross-sectional area
- (C) Veins: due to blood flow against the gravity
- (D) Capillaries: Due to two-way blood flow in capillaries

Q39. BIO

An active athlete has more stamina of running compared to an officer of same age with physically inactive lifestyle. Which of the following organelles has greatly increased in the muscle cells of athlete?

- (A) Nucleus
- (B) Mitochondria
- (C) Golgi bodies
- (D) Smooth endoplasmic reticulum (SER)

Q40. BIO

Once an action potential reaches the membrane of a skeletal muscle fiber, what is the first event that occurs in the contraction process?

- (A) Actin and myosin form a cross-bridge
- (B) Calcium is pumped back into the sarcoplasmic reticulum
- (C) Calcium is released from the sarcoplasmic reticulum
- (D) ATP is hydrolyzed by troponin

Q41. BIO

The pubic symphysis is a slightly moveable joint joined by which of the following tissue?

- (A) Elastic cartilage
- (B) Fibrocartilage
- (C) Costal cartilage
- (D) Articular cartilage

Q42. BIO

In a pea plant seed color is determined by one gene, with yellow (dominant) and green (recessive). Which parental cross would most likely result in offspring showing a 1:1 ratio of yellow to green seeds?

- (A) YY × YY
- (B) Yy × yy
- (C) Yy × Yy
- (D) YY × yy

Q43. BIO

Mendel crossed a plant with round yellow seeds (RRYY) and was a plant with wrinkled green seeds (rryy), what was the phenotype of all F1 offspring?

- (A) All round green
- (B) All round yellow
- (C) All wrinkled yellow
- (D) All wrinkled green

Q44. BIO

In normal 28 days menstrual cycle when would you expect the LH surge to occur?

- (A) Days 7–10
- (B) Days 11–14
- (C) Days 15–18
- (D) Days 19–22

Q45. BIO

Which property of water helps in moderating Earth's climate and maintaining stable temperature in aquatic environment?

- (A) Low viscosity
- (B) High specific heat
- (C) High surface tension
- (D) High density

Q46. BIO

What is the effect of increased substrate concentration on enzyme activity?

- (A) Decreases the rate of reaction
- (B) Increases the rate of reaction until all active sites are saturated
- (C) Has no effect on the reaction rate
- (D) Increases the rate of reaction continuously in a straight line

Q47. BIO

An oligosaccharide is made up of at least:

- (A) Two saccharide units
- (B) Ten saccharide units
- (C) Three to ten saccharide units
- (D) More than ten saccharide units

Q48. BIO

Which statement best explains the difference between humoral and cell mediated immune responses?

- (A) Humoral immunity involves B-lymphocytes and cell mediated immunity involves T-lymphocytes
- (B) Humoral immunity destroys viruses and cell mediated immunity destroys bacteria
- (C) Humoral immunity is specific and cell mediated immunity is nonspecific
- (D) Humoral immunity uses antibodies and cell mediated immunity does not involve immune cells

Q49. BIO

Which of the following is the correct higher (left) to lower (right) sequence of molecules with respect to their amount in the cell?

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

Q50. BIO

A person in hot weather is unable to maintain body temperature. Which physiological response has failed?

- (A) Vasodilation & sweating
- (B) Vasoconstriction
- (C) Shivering
- (D) Renin secretion

Q51. BIO

The main idea in Darwin's Theory of "Origin of species by natural selection" is:

- (A) Inheritance of acquired traits
- (B) Use and disuse of organs
- (C) Species never change
- (D) Evolution occurs through gradual accumulation of adaptation through successive generations

Q52. BIO

Which of the following is a key feature of RNA?

- (A) Deoxyribose and thymine
- (B) Double stranded and thymine
- (C) Ribose and uracil
- (D) Ribose and thymine

Q53. BIO

Which of the following types of RNA makes up the largest proportion of total cellular RNA?

- (A) Messenger RNA
- (B) Ribosomal RNA
- (C) Transfer RNA
- (D) Catalytic RNA (ribozyme)

Q54. BIO

The bacterium *Treponema Pallidum* is responsible for which sexually transmitted disease?

- (A) Syphilis
- (B) Chlamydia
- (C) Gonorrhea
- (D) Genital herpes

Q55. BIO

Tissue fluid in a lymphatic system is called as:

- (A) Plasma
- (B) Matrix
- (C) Lymph
- (D) Blood

Q56. BIO

Which one of the following biomolecules is a polymer/polysaccharide?

- (A) Sucrose
- (B) Pentose
- (C) Lactose
- (D) Glycogen

Q57. BIO

Olfactory receptors are the type of:

- (A) Photoreceptors
- (B) Mechanoreceptors
- (C) Thermoreceptors
- (D) Chemoreceptors

Q58. BIO

Which of the following organisms eliminate nitrogenous waste mainly in the form of uric acid?

- (A) Freshwater Fish
- (B) Amphibians
- (C) Birds
- (D) Mammals

Q59. BIO

Which of the following cells possess Nissl's granules?

- (A) Nerve cells
- (B) WBC
- (C) RBC
- (D) Platelets

Q60. BIO

Which part of human brain is involved in maintaining the posture and balance of the body?

- (A) Cerebrum
- (B) Cerebellum
- (C) Hypothalamus
- (D) Medulla oblongata

Q61. BIO

Arthritis is:

- (A) Inflammation of joints
- (B) Infection of intervertebral disc
- (C) Fusion of vertebral joint
- (D) Tingling along the length of legs

Q62. BIO

Which type of joint is present in pubis?

- (A) Fibrous joints
- (B) Immoveable joints
- (C) Cartilaginous joints
- (D) Freely moveable joints

Q63. BIO

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

- (A) Motor neurons
- (B) Sensory neurons
- (C) Interneurons
- (D) Relay neurons

Q64. BIO

Which of the following statements best compares cell division in prokaryotic and Eukaryotic cells?

- (A) Eukaryotes divide by budding; prokaryotes by mitosis
- (B) Eukaryotes use binary fission; prokaryotes by meiosis
- (C) Eukaryotes divide by mitosis; prokaryotes by binary fission
- (D) Both use mitosis for cell division

Q65. BIO

Which of the following best describes "acquired characteristics" according to Lamarckism?

- (A) Traits caused by mutation
- (B) Traits inherited from parents
- (C) Traits acquired by use or disuse
- (D) Traits selected by nature

Q66. BIO

According to Lock and Key model, the active site is regarded as:

- (A) Rigid and specific
- (B) Flexible and specific
- (C) Rigid and non specific
- (D) Flexible and non specific

Q67. BIO

Peptide bonds are important in protein because they:

- (A) Affect solubility
- (B) Hold R-groups
- (C) Link amino acid
- (D) Help in releasing oxygen

Q68. BIO

Why are retroviruses placed in a separate class of RNA viruses?

- (A) They always infect animal cells only
- (B) Their RNA acts directly as mRNA
- (C) They lack protein coats
- (D) They use reverse transcriptase to make DNA from RNA

Q69. BIO

Reversible inhibitors differ from irreversible inhibitors because they:

- (A) Binds permanently and cannot be removed
- (B) Bind temporarily and can be removed
- (C) Permanently inactivate the enzyme
- (D) Change enzyme structure permanently

Q70. BIO

Which is an enzyme activator secreted by the intestinal glands:

- (A) Amylase
- (B) Pepsinogens
- (C) Enterokinase
- (D) Lipase

Q71. BIO

In which of the following combination, both components have Hyaline cartilage?

- (A) Epiglottis & intervertebral disc
- (B) Trachea & intervertebral disc
- (C) Nose & pinna
- (D) Nose & trachea

Q72. BIO

According to Lamarck, the evolution of long necks in giraffes is explained by:

- (A) Natural selection
- (B) Genetic mutation
- (C) Survival of the fittest
- (D) Stretching of necks over generations

Q73. BIO

The process of spermatogenesis occurs in which part of the male reproductive system?

- (A) Seminiferous tubules
- (B) Vas deferens
- (C) Scrotum
- (D) Epididymis

Q74. BIO

Which layer of uterus nourishes the embryo after implantation?

- (A) Cervical epithelium
- (B) Myometrium
- (C) Endometrium
- (D) Perimetrium

Q75. BIO

The main role of mRNA during protein synthesis is to:

- (A) Carry genetic information for protein synthesis
- (B) Stabilize ribosome
- (C) Deliver amino acids
- (D) Provide platform for proteins synthesis

Q76. BIO

Glycoproteins are formed as a result of the combination of:

- (A) Lipids and proteins
- (B) Carbohydrates and proteins
- (C) Nucleic acid and proteins
- (D) Fatty acids and carbohydrates

Q77. BIO

A student observed a boundary in both plant and animal cells that controls entry and exit of substances. Which of the following structures is likely being observed?

- (A) Mitochondria
- (B) Golgi apparatus
- (C) Plasma membrane
- (D) Cell wall

Q78. BIO

If a normal person marries with colour blind female what will be the possibility of normal male child:

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

Q79. BIO

Which of the following characters is shared by both skeletal and cardiac muscles?

- (A) Presence of Striation
- (B) Involuntary control
- (C) Multinucleated fibers
- (D) Intercalated discs

Q80. BIO

Which of the following muscle types are involuntary in action?

- (A) Skeletal and smooth
- (B) Skeletal and cardiac
- (C) Cardiac and smooth
- (D) Smooth muscle only

Q81. BIO

In which of the following combinations, both components have non-striated muscle fibers?

- (A) Intestine & biceps
- (B) Intestine & blood vessels
- (C) Heart & lungs
- (D) Stomach & heart

CHEM SECTION: CHEMISTRY

Questions 82 to 126 (45 MCQs)

Q82. CHEM

Value of R gas constant in $\text{J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$ is:

- (A) 8.314
(B) 62.4
(C) 0.821
(D) 62400

Q83. CHEM

Which of the following best explains why phenol reacts with aqueous NaOH, but alcohols do not?

- (A) Phenol has a lower boiling point than alcohol.
(B) Alcohols contain a strong OH bond that cannot be broken by weak bases.
(C) Phenol forms hydrogen bonding that facilitates ionization.
(D) Phenol is weakly acidic due to resonance stabilization of phenoxide ion.

Q84. CHEM

In propene, the π -bond is formed by sideways overlap of:

- (A) s-orbitals
(B) p-orbitals
(C) sp^3 hybrid orbitals
(D) sp^2 hybrid orbitals

Q85. CHEM

An enzyme used to decompose the lipids into fatty acids in our alimentary canal is:

- (A) Amylase
(B) Protease
(C) Lipase
(D) Urease

Q86. CHEM

Molecules having one lone pair and three bond pairs have geometrical shape:

- (A) Bent or angular
(B) Trigonal
(C) Trigonal pyramidal
(D) Trigonal planar

Q87. CHEM

Conversion of dihaloalkane into alkyne does not involve:

- (A) Addition
(B) Elimination
(C) Base
(D) Heat

Q88. CHEM

Majority of reactions taking place at ordinary temperatures with $-\Delta H$ are:

- (A) Endothermic
(B) Exothermic
(C) Thermally unstable
(D) Reversible

Q89. CHEM

Which one of the following is a coinage metal?

- (A) Pd
(B) Cd
(C) Hg
(D) Cu

Q90. CHEM

Consider the given balanced chemical equation: $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$. If 4 g of H_2 reacts with 32 g of O_2 to produce 28 g of H_2O , what is the percentage yield of the reaction?
(Molar mass of $\text{H}_2 = 2 \text{ g/mol}$, $\text{O}_2 = 32 \text{ g/mol}$, and $\text{H}_2\text{O} = 18 \text{ g/mol}$)

- (A) 63.6%
(B) 77.8%
(C) 87.5%
(D) 92.5%

Q91. CHEM

The amount of energy needed to weaken the existing bonds to an extent that can be broken through collision is called:

- (A) Bond energy
(B) Activation energy
(C) Average energy
(D) Enthalpy

Q92. CHEM

Oxidation numbers of X, Y, Z are +6, -2, & -1 respectively, possible molecular formula when atoms combine:

- (A) XYZ_2
(B) XY_2Z
(C) XY_2Z_2
(D) X_2YZ

Q93. CHEM

Which set of quantum numbers is not allowed for an electron?

- (A) $n = 1, l = 0, m = 0, s = +1/2$
(B) $n = 3, l = 0, m = 0, s = -1/2$
(C) $n = 2, l = 2, m = 1, s = +1/2$
(D) $n = 2, l = 1, m = 0, s = +1/2$

Q94. CHEM

For $2\text{A} + 2\text{B} \rightarrow 3\text{C}$, which of the following does not express the reaction rate?

- (A) $\frac{d[\text{C}]}{dt}$
(B) $-\frac{d[\text{B}]}{dt}$
(C) $-\frac{1}{2} \frac{d[\text{A}]}{dt}$
(D) $-\frac{1}{3} \frac{d[\text{C}]}{dt}$

Q95. CHEM

Pick the order of ease of reduction of H^+ , Cu^{2+} , and Ag^+ :

- (A) $\text{H}^+ > \text{Ag}^+ > \text{Cu}^{2+}$
(B) $\text{Ag}^+ > \text{Cu}^{2+} > \text{H}^+$
(C) $\text{Ag}^+ > \text{H}^+ > \text{Cu}^{2+}$
(D) $\text{H}^+ > \text{Cu}^{2+} > \text{Ag}^+$

Q96. CHEM

Acetaldehyde undergoes oxidation to produce acetic acid. In this reaction, the oxidizing agent used is:

- (A) LiAlH_4
- (B) $\text{K}_2\text{Cr}_2\text{O}_7$
- (C) LiNH_2
- (D) NaBH_4

Q97. CHEM

Which one of the following has higher vapour pressure?

- (A) Acetone
- (B) Acetaldehyde
- (C) Isopentane
- (D) Benzene

Q98. CHEM

Terminal alkynes show acidic character due to:

- (A) Terminal carbon atoms are sp^3 hybridized
- (B) Terminal carbon atoms are sp hybridized
- (C) Terminal carbon atoms are sp^2 hybridized
- (D) Terminal carbon atoms show hydrogen bonding.

Q99. CHEM

FISCHER ESTERIFICATION is which type of reaction

- (A) Condensation
- (B) Substitution
- (C) Elimination
- (D) Hydrogenation

Q100. CHEM

Shape of orbital is determined by quantum number:

- (A) n
- (B) l
- (C) m
- (D) s

Q101. CHEM

The theories which explain the formation of sigma and pi bond are EXCEPT:

- (A) MOT
- (B) VBT
- (C) VSEPR
- (D) CFT

Q102. CHEM

The value of Planck's constant is:

- (A) $6.6262 \times 10^{-30} \text{ J} \cdot \text{sec}$
- (B) $6.6262 \times 10^{-32} \text{ J} \cdot \text{sec}$
- (C) $6.6262 \times 10^{-34} \text{ J} \cdot \text{sec}$
- (D) $6.6262 \times 10^{-34} \text{ J} \cdot \text{sec}$

Q103. CHEM

Final equation for the representation of rate of reaction in term of concentration is called

- (A) Rate law
- (B) Rate constant
- (C) Reaction rate
- (D) Reaction order

Q104. CHEM

Poly vinyl chloride (PVC) is the type of?

- (A) Homopolymer
- (B) Thermosetting polymer
- (C) Thermoplastic polymer
- (D) Copolymer

Q105. CHEM

Which of the following is true about pressure for an ideal gas at -273°C ?

- (A) $P = 1 \text{ atm}$
- (B) $P = 2 \text{ atm}$
- (C) $P = 3 \text{ atm}$
- (D) $P = 0 \text{ atm}$

Q106. CHEM

Which of the following is a basic buffer?

- (A) $\text{NH}_4\text{OH}/\text{NH}_4\text{Cl}$
- (B) NaOH/NaCl
- (C) NaOH/HCl
- (D) $\text{H}_2\text{CO}_3/\text{NaHCO}_3$

Q107. CHEM

What happens when H^+ is added to ammonium hydroxide and ammonium chloride buffer?

- (A) More ammonium hydroxide is formed
- (B) The reaction will move reverse
- (C) The reaction will move forward
- (D) No effect on equilibrium

Q108. CHEM

What is general requirement for free radical substitution reaction of ethane and halogen?

- (A) Low pressure
- (B) Low temperature
- (C) High pressure
- (D) Heat and UV light

Q109. CHEM

Which one of the following is not a characteristic of benzene?

- (A) Aromaticity
- (B) Stability
- (C) to follow Huckle rule
- (D) High reactivity

Q110. CHEM

Correct arrangement of orbital according to size of hybridized orbitals

- (A) $\text{sp} > \text{sp}^2 > \text{sp}^3$
- (B) $\text{sp}^2 > \text{sp} > \text{sp}^3$
- (C) $\text{sp}^3 > \text{sp}^2 > \text{sp}$
- (D) $\text{sp}^3 > \text{sp} > \text{sp}^2$

Q111. CHEM

Consider the equation $\text{H}_2 + \text{O}_2 \rightarrow \text{H}_2\text{O}$, what volume of hydrogen gas is required to produce 1 mol of water at standard temperature & pressure?

- (A) 11.2 dm³
- (B) 22.4 dm³
- (C) 18 dm³
- (D) 58 dm³

Q112. CHEM

A chemical reaction has a theoretical yield of 25g, but only 20g of product was obtained. What is the percentage yield of the reaction?

- (A) 20%
- (B) 25%
- (C) 45%
- (D) 80%

Q113. CHEM

Which of the following situations most clearly demonstrates a key characteristic of a Redox reaction?

- (A) Water boiling to steam
- (B) Hydrogen gas reacting with chlorine to form hydrogen chloride gas
- (C) Sodium chloride dissolving in water
- (D) Ethanol evaporating at room temperature

Q114. CHEM

If 100 kJ of heat is absorbed by the system and 40 kJ of work is done on the system what is the change of internal energy?

- (A) -60 kJ
- (B) +60 kJ
- (C) -140 kJ
- (D) +140 kJ

Q115. CHEM

Number of unpaired electrons present in the ground state of Fe^{3+} (Atomic number of Fe=26):

- (A) Three
- (B) Four
- (C) Five
- (D) Six

Q116. CHEM

If % yield and actual yield is 80 and 20 g respectively, what will be theoretical yield?

- (A) 20 g
- (B) 25 g
- (C) 30 g
- (D) 40 g

Q117. CHEM

Which of the following best identifies the redox reaction?

- (A) transfer of proton
- (B) transfer of electron
- (C) absorption of light
- (D) exchange of ions

Q118. CHEM

Methanol is produced by reduction of

- (A) Formaldehyde
- (B) Acetaldehyde
- (C) Propanal
- (D) Propanone

Q119. CHEM

IUPAC name of $(\text{CH}_3)_3\text{CCH}_2\text{Br}$ is

- (A) 1-bromopentane
- (B) 1-bromo-2,2-trimethylethane
- (C) 1-bromo-2,2-dimethylpropane
- (D) 2-bromopentane

Q120. CHEM

Which one shows anisotropic behavior?

- (A) Wood
- (B) Gemstone
- (C) Coke
- (D) Graphite

Q121. CHEM

In a unit cell of a crystal lattice the angle β is between faces:

- (A) a and b
- (B) a and c
- (C) a and a
- (D) not specified

Q122. CHEM

Pick the crystalline solid:

- (A) Cement
- (B) Ceramics
- (C) Concrete
- (D) Copper

Q123. CHEM

Number of unpaired electrons in Boron in ground state is/are:

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

Q124. CHEM

Chlorination of benzene in the presence of iron (III) chloride involves mechanism of:

- (A) Electrophilic addition
- (B) Electrophilic Substitution
- (C) Free radical Substitution
- (D) Free radical halogenation

Q125. CHEM

The element with smallest value of Ionization energy is

- (A) Li
- (B) Al
- (C) Ca
- (D) Ba

Q126. CHEM

Carboxylic acid reacts with ammonia to form ammonium salts which on heating produces

- (A) Carbonates
 - (B) Alkane
 - (C) Ester
 - (D) Amide
-

PHY SECTION: PHYSICS

Questions 127 to 162 (36 MCQs)

Q127. PHY

If P is the momentum of an object and m is its mass, then its kinetic energy is:

- (A) $\frac{P}{2m}$
- (B) $\frac{P^2}{2m}$
- (C) $\frac{1}{2}Pm^2$
- (D) $\frac{1}{2}P^2m$

Q128. PHY

The electric field at a point due to two equal and opposite charges is 100 N/C. If the magnitude of each charge is doubled then the electric field at that point becomes:

- (A) 50 N/C
- (B) 100 N/C
- (C) 200 N/C
- (D) 400 N/C

Q129. PHY

If a plastic sheet of relative permittivity 2.5 is inserted between two point charges placed in a vacuum, then the electrostatic force between them

- (A) Increases by a factor of 2.5
- (B) Decreases by a factor of 2.5
- (C) Increases by a factor of 5
- (D) Decreases by a factor of 5

Q130. PHY

After 3 half-lives, the remaining fraction of a radioactive sample is:

- (A) $1/2$
- (B) $1/4$
- (C) $1/8$
- (D) $1/16$

Q131. PHY

If the horizontal range of a projectile becomes half of its maximum possible horizontal range, the probable angle of projection is;

- (A) 15°
- (B) 30°
- (C) 45°
- (D) 60°

Q132. PHY

In an ideal transformer, if the primary voltage is doubled and the turns ratio remains the same, what happens to the secondary current?

- (A) Doubles
- (B) Halves
- (C) Remains the same
- (D) Becomes four times

Q133. PHY

An angular displacement of 90° is equal to:

- (A) One-fourth revolution
- (B) One-third revolution
- (C) One-half revolution
- (D) One complete revolution

Q134. PHY

The time in which half of the given number of radioactive nuclei decay is known as

- (A) $1/2$ life of radioactive element
- (B) $2/3$ life of radioactive element
- (C) $3/4$ life of radioactive element
- (D) $2/5$ life of radioactive element

Q135. PHY

Earth receives large amount of energy directly from:

- (A) Wind
- (B) Water
- (C) Sun
- (D) Moon

Q136. PHY

A phase difference of 90° is equal to:

- (A) π radians
- (B) $\pi/2$ radians
- (C) 2π radians
- (D) $\pi/4$ radians

Q137. PHY

The reciprocal of the resistivity of a material is called its:

- (A) Impedance
- (B) Conductivity
- (C) Admittance
- (D) Reactance

Q138. PHY

The Balmer series of hydrogen spectrum appears in the:

- (A) Infrared region
- (B) Ultraviolet region
- (C) X-ray region
- (D) Visible region

Q139. PHY

A ball is thrown into the air with certain velocity v making an angle θ with horizontal. If air resistance is neglected, then at maximum height, its velocity is:

- (A) Equal to initial velocity
- (B) Half of initial velocity
- (C) Equal to zero
- (D) Minimum but not zero

Q140. PHY

A cannon is placed on a smooth surface. When it fires a shell, the cannon moves backward. This recoil occurs due to:

- (A) Law of conservation of energy
- (B) Backward thrust of the gases
- (C) Newton's third law of motion
- (D) Newton's first law of motion

Q141. PHY

If the surface charge density of an infinite sheet increases by 25%, the electric field intensity:

- (A) Increases by 25%
- (B) Increases by 50%
- (C) Decreases by 25%
- (D) Remains the same

Q142. PHY

An incompressible fluid flows through a pipe that becomes narrower in one section. The fluid speed increases in that region to maintain:

- (A) Constant pressure
- (B) Constant energy
- (C) Constant mass flow rate
- (D) Constant volume

Q143. PHY

In a pipe of varying cross-section, as fluid enters the narrower region, it exhibits:

- (A) High velocity, high pressure
- (B) High velocity, low pressure
- (C) Low velocity, high pressure
- (D) Low velocity, low pressure

Q144. PHY

The curved shape of an airplane wing causes air to move faster over the top surface. This leads to:

- (A) Greater pressure on the top
- (B) Lower pressure on the top
- (C) Equal pressure on both sides
- (D) Zero pressure above the wing

Q145. PHY

The protons in the nucleus of an atom do not exit out due to the:

- (A) Electromagnetic force
- (B) Gravitational force
- (C) Weak nuclear force
- (D) Strong nuclear force

Q146. PHY

Mechanical waves cannot travel through outer space because they:

- (A) Have low speed in vacuum
- (B) Disperse in space due to long wavelength
- (C) Lose frequency in the absence of air
- (D) Require interacting particles for transmission

Q147. PHY

The terminal voltage of a cell equals its EMF only when:

- (A) No current flows
- (B) Current is maximum
- (C) Internal resistance is infinite
- (D) Load resistance is zero

Q148. PHY

If a loop moves toward a stationary magnet, the induced current will:

- (A) Enhance the motion
- (B) Try to stop the approach
- (C) Become zero
- (D) Become alternating

Q149. PHY

The energy of a Simple Harmonic oscillation depends upon the

- (A) Frequency
- (B) Time period
- (C) Wavelength
- (D) Amplitude

Q150. PHY

The wave that has the highest frequency and penetrating power is

- (A) X-rays
- (B) Ultraviolet rays
- (C) Gamma rays
- (D) Microwaves

Q151. PHY

According to First law of thermodynamics when heat flows into a system and no work is done, the internal energy of the system must

- (A) Increase
- (B) Decrease
- (C) Remains constant
- (D) Becomes zero

Q152. PHY

If the length of the conductor is made 4 times its original length, its resistance becomes

- (A) Quarter
- (B) Half
- (C) Zero
- (D) 4 times

Q153. PHY

The unit of temperature coefficient of resistivity is

- (A) $1/^\circ\text{C}$
- (B) $1/^\circ\text{K}$
- (C) $1/\text{A}$
- (D) $1/\Omega$

Q154. PHY

The work done by the gravitational force on an object as it moves from a reference level to a higher point is:

- (A) Always positive
- (B) Always negative
- (C) Zero
- (D) Depends on the path taken

Q155. PHY

If two speakers emit sound at same frequency and phase, maximum loudness occurs when:

- (A) Path difference = $\lambda/2$
- (B) Path difference = λ
- (C) Path difference = $\lambda/4$
- (D) Path difference = $3\lambda/4$

Q156. PHY

When an object attains terminal velocity, its acceleration is:

- (A) 9.8 m/s^2
- (B) Zero
- (C) 1 m/s^2
- (D) 9.8 m/s

Q157. PHY

A 0.5 kg ball moving at 6 m/s has kinetic energy

- (A) 9 J
- (B) 18 J
- (C) 6 J
- (D) 3 J

Q158. PHY

A fluid is flowing through a tube, to undergo transition from laminar to turbulent flow its velocity must be:

- (A) Slightly less than critical velocity
- (B) Equal to critical velocity
- (C) Greater than critical velocity
- (D) Increasing gradually but less than critical velocity

Q159. PHY

For two equal positive charges, the electric field weakest?

- (A) Midway between them
- (B) Along the perpendicular bisector
- (C) Close to either charge
- (D) At infinity

Q160. PHY

A projectile is launched in air with certain angle; its velocity is maximum at:

- (A) Point of projection
- (B) Highest point
- (C) Between launching and highest point
- (D) At all points

Q161. PHY

If the distance between two charges is halved and magnitude of charges are also doubled, then the force between these charges becomes:

- (A) two times
- (B) four times
- (C) eight times
- (D) sixteen times

Q162. PHY

If a body having mass m_1 (2kg), moving with 5 m/s approaches another mass, m_2 (3kg) with speed of 1 m/s in same direction, relative speed of approach is 4 m/s. Relative speed of separation after collision will be:

- (A) 4 m/s
- (B) 2 m/s
- (C) 6 m/s
- (D) depends on masses

ENG SECTION: ENGLISH

Questions 163 to 171 (9 MCQs)

Q163. ENG

Which of the following sentence has correct subject verb agreement?

- (A) The teacher give the students homework.
- (B) The teacher gives the students homework.
- (C) The teachers gives the student homework.
- (D) The teachers given the student homework.

Q164. ENG

The keys were found _____ the drawer where you left them last week.

- (A) under
- (B) in
- (C) on
- (D) beside

Q165. ENG

Identify the sentence among of the following, which is punctuated correctly?

- (A) The teaching staff asked the principal what time the meeting would start.
- (B) The teaching staff asked the principal: "What time would the meeting start"?
- (C) The teaching staff asked the principal, "What time would the meeting start?"
- (D) The teaching staff asked the principal; "What time would the meeting start"?

Q166. ENG

She was elated when she got first position In exams." What is the meaning of "elated" In this sentence?

- (A) Disappointed
- (B) Worried
- (C) Excited
- (D) Mad

Q167. ENG

The board of directors expressed _____ disappointment with the financial results.

- (A) their
- (B) its
- (C) his or her
- (D) one's

Q168. ENG

It rained all night; _____ the roads were flooded in the morning.

- (A) similarly
- (B) instead
- (C) as a result
- (D) in contrast

Q169. ENG

The manager accepted the cashier's _____ for coming late.

- (A) explanation
- (B) explaination
- (C) explication
- (D) explanasion

Q170. ENG

The writer has unearthed serious irregularities in the entire project. The word 'unearthed' in this sentence means

- (A) written
- (B) mentioned
- (C) exposed
- (D) created

Q171. ENG

Identify the sentence with no spelling error:

- (A) Imtiaz invited me on a dinner party at the restaurant.
- (B) Imtiaz invited me on a diner party at restaurant.
- (C) Imtiaz invited me on a dinner party at resturant.
- (D) Imtiaz invited me on a dinnner party at resturant.

LOGIC SECTION: LOGICAL REASONING

Questions 172 to 180 (9 MCQs)

Q172. LOGIC

What will come next? 1, 4, 2, 5, 3, 6, 4, 7, ?

- (A) 5
- (B) 6
- (C) 7
- (D) 8

Q173. LOGIC

All daffodils are plants. All plants are living things. Some living things are real.

Conclusions:

- I. All daffodils are living things.
- II. Some living things are flowers.
- III. All daffodils are real.

Which conclusions follow?

- (A) Only I
- (B) Only I and II
- (C) Only II and III
- (D) All follow

Q174. LOGIC

One apple pie has 10 slices, and each apple pie feeds five people. Henry is having a party with 200 people. How many slices of pie does he need?

- (A) 200
- (B) 50
- (C) 400
- (D) 100

Q175. LOGIC

How many trees are in the orchard?

Which of the statements below are needed to sufficiently answer this question?

- i. Ibrahim is a farmer and looks after half of the trees in the orchard
- ii. 300 trees in the orchard are under Ibrahim's care

- (A) i is enough
- (B) ii is enough
- (C) both i and ii are needed
- (D) neither i nor ii are sufficient

Q176. LOGIC

P, Q and R are M's parents. M and N are siblings. Q is N's mother. What is P to M?

- (A) Mother
- (B) Father
- (C) Sister
- (D) Brother

Q177. LOGIC

Asad bought 50 packets of biscuits for the price of Rs. 500; whereas Anum bought 25 packets of chips for the price of Rs. 1000. While comparing the prices of packets of biscuits and chips, which of the following statements is correct?

- (A) Price of 4 packets of biscuits is equal to the price of 1 packet of chips
- (B) Price of 1 packet of biscuits is equal to the price of 4 packets of chips
- (C) Price of 2 packets of biscuits is equal to the price of 1 packet of chips
- (D) Price of 1 packet of biscuits is equal to the price of 2 packets of chips

Q178. LOGIC

The virus spreads rapidly in the town. It infected the people – First day: 8, Second day: 16, Third day: 32. What will the number of people infected on the next day?

- (A) 44 people
- (B) 64 people
- (C) 96 people
- (D) 54 people

Q179. LOGIC

Which of the following is a result of poor design that could cause an accident in the workplace?

- (A) Equipment failure
- (B) Slippery surfaces
- (C) Insufficient lighting
- (D) Unplanned workspace layout

Q180. LOGIC

Which of the following is the main cause of accidents involving equipment?

- (A) Overconfidence
- (B) Insufficient maintenance
- (C) Fatigue
- (D) Poor training

OFFICIAL VERIFIED ANSWER KEY

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

BIOLOGY
10. Homeostasis

Kidneys perform their osmoregulatory role under the effect of Antidiuretic Hormone (ADH). Which...

CORE CONCEPT & DERIVATION

Antidiuretic hormone (ADH or vasopressin) is secreted by the posterior pituitary gland to promote water conservation by increasing the permeability of the collecting ducts to water.

Formula / Rule / Reaction:

Increased ADH → Increased Aquaporin Insertion → Increased Water Reabsorption → Hypertonic, Concentrated Urine $\text{CO}_2 + \text{H}_2\text{O} \rightleftharpoons \text{H}_2\text{CO}_3 \rightleftharpoons \text{H}^+ + \text{HCO}_3^-$

Solution:

- Under water deficit or increased plasma osmolarity, osmoreceptors trigger ADH release.
- ADH acts on the V2 receptors of collecting duct epithelial cells, incorporating aquaporins into the luminal membrane.
- Water moves osmotically out of the collecting duct into the hypertonic renal medullary interstitium, leaving behind a small volume of concentrated, hypertonic urine.

Why other options are incorrect:

- **Option A:** Hypotonic urine is produced when ADH secretion is suppressed, not stimulated.
- **Option B:** Hypotonic urine with increased volume characterizes conditions of diuresis or diabetes insipidus where ADH is deficient.
- **Option D:** ADH decreases urine volume by promoting water retention; it cannot increase urine output.

Question #2 Key: (D)

BIOLOGY
12. Nervous Coordination

Which part of the brain controls the transition between sleeping and wakefulness?

CORE CONCEPT & DERIVATION

The pons contains neural circuits within the brainstem reticular formation that regulate the sleep-wake cycle and control rapid eye movement (REM) sleep.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The pons lies between the midbrain and the medulla oblongata in the brainstem.
- Pontine nuclei, in coordination with the reticular activating system, regulate transitions between non-REM sleep, REM sleep, and alertness.

Why other options are incorrect:

- **Option A:** The medulla oblongata regulates basic autonomic functions such as cardiac rate, blood pressure, and respiratory rhythm.
- **Option B:** The cerebellum coordinates voluntary motor movement, posture, and muscular equilibrium.
- **Option C:** The cerebrum mediates conscious sensory perception, voluntary motor output, reasoning, and memory storage.

Question #3 Key: (D)

BIOLOGY
12. Nervous Coordination

Which part of the brain contains central chemoreceptors that monitor [Formula] levels in the bl...

CORE CONCEPT & DERIVATION

Central chemoreceptors located on the ventrolateral surface of the medulla oblongata detect changes in the hydrogen ion and carbon dioxide concentration of the cerebrospinal fluid.

Formula / Rule / Reaction:

Solution:

- Arterial carbon dioxide readily crosses the blood-brain barrier into the cerebrospinal fluid.
- Carbonic anhydrase converts it into carbonic acid, which dissociates into bicarbonate and hydrogen ions.
- The elevated hydrogen ion concentration directly stimulates the central chemoreceptors in the medulla oblongata, driving an increase in ventilation rate.

Why other options are incorrect:

- **Option A:** The pons contains the pneumotaxic and apneustic centers which modulate the respiratory pattern, but not the primary central chemoreceptors.
- **Option B:** The midbrain integrates visual and auditory reflex signals.
- **Option C:** The hypothalamus regulates autonomic homeostatic functions such as body temperature, hunger, and osmoregulation.

Question #4 Key: (D)

BIOLOGY
12. Nervous Coordination

Which component of a reflex arc connects the sensory neuron to the motor neuron within the spin...

CORE CONCEPT & DERIVATION

In a polysynaptic reflex arc, associative neurons (also termed interneurons or relay neurons) connect the afferent sensory pathway to the efferent motor pathway within the central nervous system.

Formula / Rule / Reaction:

Stimulus → Receptor → Sensory Neuron → Associative Neuron (CNS) → Motor Neuro

Solution:

- Sensory neurons enter the dorsal horn of the spinal cord via the dorsal root.
- Associative neurons located entirely within the gray matter of the spinal cord integrate the incoming sensory information.
- The associative neuron synapses with motor neurons in the ventral horn, which transmit impulses to the effector organ.

Why other options are incorrect:

- **Option A:** Receptors are specialized peripheral structures that transduce external stimuli into nerve impulses.
- **Option B:** Effectors are muscles or glands that carry out the physiological response.
- **Option C:** Muscle fibers act as effector tissues; they do not transmit impulses between neurons within the spinal cord.

Question #5 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

The [Formula] dihybrid phenotypic ratio of Mendel's law of independent assortment can be affected...

CORE CONCEPT & DERIVATION

Mendel's law of independent assortment applies strictly to genes located on separate, non-homologous chromosomes or far apart on the same chromosome.

Formula / Rule / Reaction:

$$\text{Recombinant Frequency} < 50\% \implies \text{Deviation from } 9 : 3 : 3 : 1 \text{ Ratio}$$

Solution:

- Linked genes reside on the same chromosome and tend to be inherited together during gametogenesis.
- Because linked genes do not segregate independently, parental phenotypes predominate in the offspring.
- This physical linkage prevents the formation of expected recombinant frequencies, disrupting the classical 9 : 3 : 3 : 1 dihybrid phenotypic ratio.

Why other options are incorrect:

- **Option A:** Genetic drift refers to random fluctuations in allele frequencies across generations in a population, not individual cross ratios.
- **Option B:** Small population size causes statistical sampling error, but it does not biochemically alter chromosomal inheritance mechanisms.
- **Option D:** Gene duplication increases gene copy number without directly causing linkage distortion in a standard dihybrid cross.

Question #6 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

Which of the following is the best description of the process of crossing over during meiosis?

CORE CONCEPT & DERIVATION

Crossing over is the reciprocal exchange of homologous genetic segments between non-sister chromatids of paired bivalents during prophase I of meiosis.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- During the pachytene stage of prophase I, homologous chromosomes form synaptonemal complexes.
- Non-sister chromatids break and rejoin at contact points called chiasmata.
- This process produces novel recombinant alleles, increasing genetic variation in gametes.

Why other options are incorrect:

- **Option A:** Chromosome duplication occurs during the S phase of interphase prior to meiosis.
- **Option C:** Movement of homologous chromosomes to opposite spindle poles characterizes anaphase I.
- **Option D:** Separation of sister chromatids occurs during anaphase II of meiosis or anaphase of mitosis.

Question #7 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

Total number of linkage groups in a normal human is:

CORE CONCEPT & DERIVATION

A linkage group consists of all genes physically located on a particular chromosome. The number of linkage groups in any organism corresponds directly to its haploid number (n) of chromosomes.

Formula / Rule / Reaction:

$$\text{Number of Linkage Groups} = n = \frac{2n}{2} = \frac{46}{2} = 23$$

Solution:

- Humans possess 46 chromosomes in diploid cells ($2n = 46$), arranged into 23 homologous pairs.
- Because homologous chromosomes carry alleles of the same genes at identical loci, each homologous pair constitutes a single linkage group.
- Therefore, humans have 23 distinct linkage groups (in males, who possess heteromorphic sex chromosomes XY, there are technically 24 distinct groups: 22 autosomes + X + Y; however, standard curriculum textbooks state 23).

Why other options are incorrect:

- **Option A:** 2 represents the number of sex chromosomes or chromosome sets, not the total linkage groups.
- **Option C:** 46 is the diploid chromosome number ($2n$); counting 46 ignores the homology of chromosome pairs.
- **Option D:** 92 is the number of chromatids present after DNA replication in the G_2 phase. **Board Note:** The provisional UHS key erroneously marked 92 by confusing total chromatid count with linkage groups, whereas the scientifically and textbook-verified answer is 23.

Question #8 Key: (D)BIOLOGY
01. Cell

Nissl's granules are specialized structures in neurons formed by the modification of:

CORE CONCEPT & DERIVATION

Nissl bodies (Nissl granules) are prominent basophilic masses found in the cell body (soma) and dendrites of neurons, responsible for intense protein synthesis.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Ultrastructural electron microscopy reveals that Nissl granules consist of dense arrays of rough endoplasmic reticulum and free ribosomes.
- They synthesize structural proteins, peptide neurotransmitters, and enzymes necessary for neuronal function.
- Nissl bodies are absent from the axon hillock and the axon.

Why other options are incorrect:

- **Option A:** Smooth ER synthesizes lipids and sequesters calcium; it does not form Nissl bodies.
- **Option B:** Peroxisomes perform fatty acid oxidation and mitochondria generate ATP via cellular respiration.
- **Option C:** Lysosomes and vacuoles are involved in waste degradation and intracellular storage, respectively.

Question #9 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

What is the primary function of a centromere?

CORE CONCEPT & DERIVATION

The centromere is the primary constriction of a replicated chromosome that physically tethers sister chromatids and serves as the platform for kinetochore assembly.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- During the S phase, DNA replicates to form two sister chromatids.
- Cohesin proteins along the centromeric DNA hold these sister chromatids together until anaphase.
- Kinetochore proteins assemble at the centromere, allowing spindle microtubules to attach and segregate chromatids.

Why other options are incorrect:

- **Option A:** Telomeres protect chromosomal ends from enzymatic degradation and fusion.
- **Option C:** Genes located along the DNA arms carry specific genetic information for protein synthesis.
- **Option D:** Origins of replication (replication origins) are the genomic loci where DNA replication is initiated.

Question #10 Key: (D)BIOLOGY
01. Cell

All of the following are functions of lysosomes EXCEPT:

CORE CONCEPT & DERIVATION

Lysosomes are single membrane-bound cytoplasmic organelles packed with hydrolytic enzymes capable of digesting biological polymers.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Lysosomes digest endocytosed extracellular substances (phagocytosis and pinocytosis).
- They degrade worn-out cellular organelles and cellular debris via autophagy.
- Lipid synthesis is carried out enzymatically by the smooth endoplasmic reticulum, not by lysosomes.

Why other options are incorrect:

- **Option A:** Intracellular digestion of macromolecules is the primary physiological role of lysosomal acid hydrolases.
- **Option B:** Waste removal and cellular clearance occur via lysosomal degradation pathways.
- **Option C:** Autophagy involves the fusion of autophagosomes with lysosomes to recycle intracellular components.

Question #11 Key: (D)BIOLOGY
07. Circulation / Transport

The first consequence of lymphatic blockage in tissues is:

CORE CONCEPT & DERIVATION

The lymphatic system functions as an overflow drainage network that collects excess interstitial fluid and filtered plasma proteins from the tissue spaces and returns them to the venous circulation.

Formula / Rule / Reaction:

Lymphatic Obstruction → Impaired Interstitial Drainage → Lymphedema (Tissue Swelling)

Solution:

- At the arterial end of capillaries, hydrostatic pressure forces fluid into the interstitial space; most is reabsorbed at the venous end, but approximately 10 percent remains.
- Lymphatic capillaries drain this remaining interstitial fluid.
- When lymphatic vessels become obstructed, this protein-rich fluid cannot drain, leading directly to localized swelling and fluid accumulation (edema).

Why other options are incorrect:

- **Option A:** Oxygen deficiency (hypoxia) is caused by compromised arterial blood delivery, not primary lymphatic blockage.
- **Option B:** Loss of nerve signaling arises from direct mechanical nerve compression or neuropathies, not directly from fluid buildup initially.
- **Option C:** Localized lymphatic blockage does not cause an immediate drop in systemic blood pressure.

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

Which part of the brain acts as an auditory relay center and controls reflex movements of the e...

CORE CONCEPT & DERIVATION

The tectum of the midbrain contains four colliculi (corpora quadrigemina) that act as visual and auditory reflex coordination centers.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The superior colliculi of the midbrain integrate visual stimuli to control reflexive tracking and movement of the head and eyes.
- The inferior colliculi of the midbrain function as relay centers for auditory signals heading toward the thalamus and auditory cortex.
- Therefore, the midbrain mediates both auditory relay and ocular reflex movements.

Why other options are incorrect:

- **Option A:** The forebrain mediates conscious sensory analysis, voluntary movement, emotions, and higher cognitive processing.
- **Option B:** The cerebellum coordinates complex motor activity, precision, and muscular balance.
- **Option D:** The medulla oblongata governs cardiorespiratory autonomic reflex centers.

Question #13 Key: (A)BIOLOGY
12. Nervous Coordination

Which of the following is the correct pathway of nerve impulse?

CORE CONCEPT & DERIVATION

A nerve impulse follows a unidirectional path from sensory detection through central nervous processing to the peripheral response organ.

Formula / Rule / Reaction:

Receptors (Afferent input) → Central Nervous System (Processing) → Effectors (Efferent response)

Solution:

- Sensory receptors transduce external or internal physical stimuli into electrochemical signals.
- Sensory neurons transmit these afferent impulses to the central nervous system (spinal cord and brain) for integration.
- Motor neurons carry efferent commands from the CNS to effector organs (muscles or glands) to generate a response.

Why other options are incorrect:

- **Option B:** Places effectors before receptors, which reverses the sensory detection sequence.
- **Option C:** Suggests the signal originates spontaneously in the CNS and ends at sensory receptors.
- **Option D:** Transmits impulses from effectors to receptors, which contradicts nervous system circuitry.

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

The neurotransmitters are secreted by the neuron from:

CORE CONCEPT & DERIVATION

Neurotransmitters are chemical signaling molecules stored inside synaptic vesicles at the terminal boutons of axons and released into the synaptic cleft upon depolarization.

Formula / Rule / Reaction:Action Potential → Opening of Voltage-Gated Ca^{2+} Channels → Exocytosis at Axon Terminal**Solution:**

- When an action potential invades the axon terminal (synaptic knob), voltage-gated calcium channels open.
- Calcium influx triggers the fusion of synaptic vesicles with the presynaptic axon terminal membrane.
- Neurotransmitters diffuse across the synaptic cleft to bind specific receptors on the postsynaptic membrane.

Why other options are incorrect:

- **Option B:** Dendrites receive chemical signals via postsynaptic receptors; they do not secrete neurotransmitters into the synapse.
- **Option C:** Nissl's granules are sites of protein synthesis in the perikaryon; they do not secrete neurotransmitters across synaptic junctions.
- **Option D:** The cell body houses metabolic and synthetic machinery but does not mediate classical synaptic exocytosis into the target synapse.

Question #15 Key: (C)BIOLOGY
12. Nervous Coordination

Hippocampus plays an important role in the:

CORE CONCEPT & DERIVATION

The hippocampus is a seahorse-shaped component of the limbic system located in the medial temporal lobe, essential for memory consolidation.

Formula / Rule / Reaction:Short-term Memory $\xrightarrow{\text{Hippocampal Consolidation}}$ Long-term Memory (Cortex)**Solution:**

- The hippocampus processes and consolidates incoming information, converting labile short-term memories into stable, long-term cortical memories.
- Bilateral damage to the hippocampus results in anterograde amnesia, rendering an individual unable to establish new long-term declarative memories.

Why other options are incorrect:

- **Option A:** Short-term working memory is primarily held and manipulated by the prefrontal cortex.
- **Option B:** Image formation on the retina is an optical process governed by the refractive media of the eye (cornea and crystalline lens).
- **Option D:** The amygdala is the primary limbic structure responsible for the generation and processing of emotional responses like fear and aggression.

Question #16 Key: (B)BIOLOGY
03. Enzymes

Enzymes activity decreases at very low or high pH because:

CORE CONCEPT & DERIVATION

Enzymes are globular proteins whose catalytic activity requires a precise three-dimensional active site conformation stabilized by ionic, hydrogen, and hydrophobic interactions.

Formula / Rule / Reaction:

Extreme pH → Disruption of Ionic/Hydrogen Bonds → Enzyme Denaturation

Solution:

- Extreme concentrations of H^+ or OH^- ions alter the ionization states of acidic and basic amino acid side chains.
- This changes the tertiary structure and active site geometry of the enzyme.
- The enzyme denatures, preventing the substrate from binding and dramatically lowering catalytic efficiency.

Why other options are incorrect:

- **Option A:** Changes in pH do not directly increase or decrease the concentration of substrate present.
- **Option C:** As catalytic activity diminishes due to denaturation, product formation decreases, not increases.
- **Option D:** Temperature constancy is an independent environmental parameter and does not account for pH-induced enzyme deactivation.

Question #17 Key: (D)BIOLOGY
02. Biomolecules

The complementary base pairing in DNA is important because it:

CORE CONCEPT & DERIVATION

Watson-Crick base pairing (adenine with thymine, guanine with cytosine) establishes a template mechanism for high-fidelity semiconservative DNA replication and transcription.

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

- Each parent DNA strand serves as a template during replication.
- Because adenine specifically pairs with thymine and guanine with cytosine, DNA polymerase adds complementary nucleotides with high precision.
- This complementary structure allows accurate preservation and transmission of genetic information across cell generations.

Why other options are incorrect:

- **Option A:** The tertiary structure of enzymes is maintained by intramolecular interactions between amino acid R-groups, not by DNA base pairs.
- **Option B:** Cellular metabolic energy is supplied by ATP hydrolysis, not by DNA base pairing.
- **Option C:** Protein folding is governed by the primary amino acid sequence and molecular chaperones.

Question #18 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics

A mature duplicated chromosome consists of:

CORE CONCEPT & DERIVATION

Following semiconservative replication during the S phase of interphase, each duplicated chromosome is composed of two sister chromatids joined at the centromere.

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

- Before replication, a chromosome consists of a single double-helical DNA molecule.
- During the S phase, DNA replicates so that the resulting duplicated chromosome possesses two identical sister chromatids.
- Each sister chromatid contains one complete, identical double-stranded DNA molecule.

Why other options are incorrect:

- **Option B:** Sister chromatids are replicated copies of one another; they possess identical, not different, DNA nucleotide sequences.
- **Option C:** A single DNA molecule cannot span across two distinct sister chromatids; each chromatid has its own distinct double helix.
- **Option D:** In nucleosomes, DNA wraps around a histone core, but this describes chromatin substructure, not the composition of a duplicated chromosome.

Question #19 Key: (C)BIOLOGY
04. Bioenergetics

The most primitive respiratory process occurring in a living cell is:

CORE CONCEPT & DERIVATION

Glycolysis is the fundamental, universal metabolic pathway that oxidizes glucose into pyruvate in the cytoplasm without requiring oxygen or organelle compartmentalization.

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

- Glycolysis is present in nearly all living organisms (both prokaryotes and eukaryotes).
- It operates anaerobically in the cytosol and evolved in the oxygen-deficient atmosphere of early Earth, predating membrane-bound mitochondria.
- Fermentation pathways represent alternative downstream branches to regenerate NAD^+ , but glycolysis is the foundational, most primitive respiratory pathway.

Why other options are incorrect:

- **Option A:** Lactic acid fermentation is a specialized secondary anaerobic adaptation downstream of glycolysis.
- **Option B:** Alcoholic fermentation is another downstream pathway utilized by yeasts and certain microorganisms.
- **Option D:** The Krebs cycle requires oxygen indirectly, occurs in mitochondria, and evolved much later with the advent of aerobic metabolism.

Question #20 Key: (B)BIOLOGY
14. Reproduction

Receive, retain and nourish a fertilized ovum is the main function of:

CORE CONCEPT & DERIVATION

The uterus (womb) is a thick-walled, muscular female pelvic organ whose endometrial lining is specialized to receive, implant, and sustain the developing embryo.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The fertilized blastocyst migrates into the uterine cavity and implants into the vascular endometrium.
- The uterus provides nutritional exchange via the placenta, retains the growing fetus within the myometrium, and protects it throughout gestation.

Why other options are incorrect:

- **Option A:** The cervix is the lower cylindrical neck of the uterus that acts as a physical barrier and mucus-producing gateway.
- **Option C:** The ovaries produce female gametes (oocytes) and synthesize endocrine sex hormones (estrogen and progesterone).
- **Option D:** The oviduct (fallopian tube) is the site of fertilization and conveys the zygote toward the uterus.

Question #21 Key: (D)BIOLOGY
09. Respiration / Gaseous Exchange*The primary function of larynx is:***CORE CONCEPT & DERIVATION**

The larynx (voice box) is a cartilaginous structure connecting the pharynx to the trachea that houses the vocal cords responsible for phonation.

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

- Air expelled from the lungs passes between the vocal folds of the larynx.
- Vocal cord vibration produces sound waves modulated by the tongue, lips, and oral cavity into human speech.

Why other options are incorrect:

- **Option A:** Humidification of inspired air occurs primarily within the nasal cavities via the rich vascular submucosa.
- **Option B:** Dust filtration is performed by coarse nasal vibrissae and the mucociliary escalator of the respiratory tract.
- **Option C:** Gaseous exchange occurs exclusively across the thin respiratory membrane of pulmonary alveoli.

Question #22 Key: (B)BIOLOGY
14. Reproduction*During menstrual cycle, luteinizing hormone (LH) is secreted due to:***CORE CONCEPT & DERIVATION**

During the mid-follicular phase, growing ovarian follicles secrete high levels of estrogen, which feeds back to inhibit FSH secretion while triggering the LH surge required for ovulation.

Formula / Rule / Reaction:
$$\text{High Estrogen} \longrightarrow \downarrow \text{FSH Secretion} \quad \& \quad \uparrow \text{GnRH Pulse Frequency} \longrightarrow \text{LH Surge}$$
Solution:

- According to Punjab Textbook Board Biology (Chapter 18), rising estrogen from the maturing Graafian follicle inhibits FSH release from the anterior pituitary.
- This decline in FSH, coupled with positive feedback from sustained high estrogen levels, stimulates the anterior pituitary to release a surge of LH.
- The mid-cycle LH surge triggers rupture of the mature follicle and release of the ovum.

Why other options are incorrect:

- **Option A:** Estrogen levels reach a high peak prior to ovulation; a decrease in estrogen does not stimulate the LH surge.
- **Option C:** An increase in FSH initiates early follicular recruitment, not the mid-cycle LH surge.
- **Option D:** While external stresses can modulate the hypothalamic axis, the biochemical driver of the LH surge is the internal endocrine feedback loop.

Question #23 Key: (B)BIOLOGY
14. Reproduction*Left and right cerebral hemispheres are connected with each other by:***CORE CONCEPT & DERIVATION**

The corpus callosum is a wide, C-shaped commissural tract of myelinated nerve fibers that links homologous cortical areas between the left and right cerebral hemispheres.

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

- The cerebral cortex is divided into two distinct hemispheres by the longitudinal cerebral fissure.
- The corpus callosum consists of over 200 million axonal projections crossing the midline to enable continuous interhemispheric communication.

Why other options are incorrect:

- **Option A:** The corpus luteum is a temporary endocrine gland that develops in the ovary following ovulation to secrete progesterone.
- **Option C:** White matter commissural tracts are composed of myelinated axons, not dendrites.
- **Option D:** Dorsal and ventral nerve roots attach spinal nerves to the spinal cord, forming part of the peripheral nervous system.

Question #24 Key: (B)BIOLOGY
11. Support & Movement*Which is the common feature between cardiac and smooth muscles?***CORE CONCEPT & DERIVATION**

Muscles are classified functionally as voluntary or involuntary based on whether their contraction is under conscious somatic control or autonomic control.

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

- Cardiac muscle (found in the heart) and smooth muscle (found in the walls of viscera and blood vessels) are innervated by the autonomic nervous system.
- Both operate unconsciously and automatically, making involuntary contraction their shared physiological feature.

Why other options are incorrect:

- **Option A:** Voluntary control is an exclusive functional property of skeletal muscle.
- **Option C:** Branching is a structural feature of cardiac muscle fibers; smooth muscle cells are unbranched and fusiform.
- **Option D:** Smooth muscle cells are unbranched, but cardiac muscle cells are branched, so this property is not shared by both.

Question #25 Key: (B)BIOLOGY
11. Support & Movement*The Joints which cause rotational movements are***CORE CONCEPT & DERIVATION**

Ball-and-socket joints are multiaxial synovial joints in which the rounded spherical head of one bone articulates within the cup-like depression of another, permitting movements in all planes including rotation.

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

- Examples of ball-and-socket joints include the shoulder (glenohumeral) and hip (acetabulofemoral) joints.
- They permit the greatest range of motion among all joint types, allowing flexion, extension, abduction, adduction, circumduction, and rotation.

Why other options are incorrect:

- **Option A:** Hinge joints (such as the elbow and knee) are uniaxial joints that permit movement in one plane only (flexion and extension).
- **Option C:** Cartilaginous joints are amphiarthrodial joints held together by cartilage, permitting slight mobility without multiaxial rotation.
- **Option D:** Sutures are immovable fibrous synarthrodial joints found between cranial bones.

Question #26 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics*Self-fertilization in plants through successive generations can lead to the development of:***CORE CONCEPT & DERIVATION**

Self-fertilization promotes homozygosity by halving heterozygosity in each successive generation according to Mendelian inbreeding principles.

Formula / Rule / Reaction:

$$\text{Heterozygosity after } n \text{ generations} = \left(\frac{1}{2}\right)^n$$

Solution:

- When plants self-fertilize continuously, alleles at each gene locus tend toward homozygosity (*AA* or *aa*).
- After multiple generations of inbreeding, the offspring become true-breeding (pure-breeding) lines that produce identical progeny upon further self-fertilization.

Why other options are incorrect:

- **Option A:** Hybrid breeds require outcrossing between genetically divergent inbred parental lines.
- **Option B:** Genetic variations decline with continued self-fertilization because inbreeding restricts novel allele combinations.
- **Option D:** Prolonged self-fertilization reduces genetic diversity and can lead to inbreeding depression rather than novel environmental adaptations.

Question #27 Key: (B)BIOLOGY
12. Nervous Coordination*Which part of the neuron typically receives incoming signals from other neurons?***CORE CONCEPT & DERIVATION**

Dendrites are highly branched cytoplasmic extensions radiating from the neuronal soma specialized for receiving synaptic inputs.

Formula / Rule / Reaction:

Dendrite (Reception) → Cell Body (Integration) → Axon (Conduction)

Solution:

- Dendrites possess dendritic spines that display neurotransmitter receptors.
- They convert incoming chemical signals from adjacent presynaptic terminals into graded local potentials directed toward the soma.

Why other options are incorrect:

- **Option A:** The axon is an elongated projection that conducts action potentials away from the soma toward target cells.
- **Option C:** The myelin sheath is an insulating lipid layer produced by Schwann cells or oligodendrocytes that enhances impulse conduction velocity.
- **Option D:** The synaptic knob is the terminal swelling of an axon specialized for storing and releasing neurotransmitters.

Question #28 Key: (B)BIOLOGY
11. Support & Movement*Why thick filaments are unable to bind with thin filament in a relaxed muscle fiber?***CORE CONCEPT & DERIVATION**

In resting skeletal muscle fibers, steric hindrance mediated by the troponin-tropomyosin complex prevents actin-myosin cross-bridge formation.

Formula / Rule / Reaction:

Low Cytosolic $[Ca^{2+}] \rightarrow$ Tropomyosin physically masks Myosin-Binding Sites on F-Actin

Solution:

- Tropomyosin is a filamentous protein lying along the grooves of the actin double helix.
- In the relaxed state (low intracellular calcium), tropomyosin covers the specific myosin-binding sites on the actin monomers.
- Myosin heads cannot interact with actin until calcium binds troponin C, shifting tropomyosin out of the binding groove.

Why other options are incorrect:

- **Option A:** Actin contains the binding sites; it does not block its own active sites.
- **Option C:** Troponin holds tropomyosin in place, but tropomyosin directly covers the binding sites.
- **Option D:** Tropomyosin does not block troponin-binding sites; troponin is structurally attached to tropomyosin along the thin filament.

Question #29 Key: (C)BIOLOGY
08. Immunity

Which of the following best highlights the importance of proteins in immunity?

CORE CONCEPT & DERIVATION

Humoral adaptive immunity relies on the synthesis of specialized gamma globulin proteins called antibodies (immunoglobulins) by differentiated plasma B-cells.

Formula / Rule / Reaction:

B-Lymphocyte → Plasma Cell → Antibody (Immunoglobulin Protein) → Neutralizes Antigen

Solution:

- Antibodies are Y-shaped globular proteins composed of two heavy and two light polypeptide chains.
- They bind specifically to target antigens on foreign pathogens, facilitating neutralization, opsonization, and complement activation.
- This specific defense function highlights the primary role of proteins in adaptive immunity.

Why other options are incorrect:

- Option A:** While certain host surface proteins act as pattern recognition receptors, acting as circulating neutralizing antibodies is the primary protective role tested.
- Option B:** Lipids (triacylglycerols) and carbohydrates (glycogen) serve as long-term and short-term energy stores, respectively.
- Option D:** Epithelial cell layers and keratinized tissues provide physical mechanical barriers, not functional specific immunity.

Question #30 Key: (B)BIOLOGY
02. Biomolecules

The secondary structure of proteins is stabilized by:

CORE CONCEPT & DERIVATIONThe secondary structure of a polypeptide chain (such as the α -helix and β -pleated sheet) is maintained by periodic hydrogen bonding between atoms of the polypeptide backbone.**Formula / Rule / Reaction:****Solution:**

- Hydrogen bonds form between the carbonyl oxygen ($C = O$) of one peptide bond and the amino hydrogen ($N - H$) of another.
- In an α -helix, this hydrogen bond occurs every fourth amino acid residue.
- These regular backbone hydrogen bonds stabilize secondary structures independently of R-group interactions.

Why other options are incorrect:

- Option A:** Ionic bonds (salt bridges) stabilize the tertiary and quaternary structures by forming between oppositely charged R-groups.
- Option C:** Covalent disulfide bridges between cysteine residues stabilize tertiary and quaternary protein conformations.
- Option D:** Hydrophobic exclusion drives the folding of nonpolar amino acid side chains into the interior during tertiary structure formation.

Question #31 Key: (C)BIOLOGY
02. Biomolecules

The following is an example of a globular protein

CORE CONCEPT & DERIVATION

Globular proteins possess a compact, spherical, three-dimensional shape formed by intricate folding, rendering them generally soluble in aqueous media and suited for dynamic physiological roles.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Hemoglobin is a tetrameric globular protein consisting of four folded polypeptide subunits (two α and two β chains).
- Its hydrophilic residues face the exterior, allowing it to dissolve in the erythrocyte cytoplasm to transport oxygen.

Why other options are incorrect:

- Option A:** Keratin is a tough, insoluble fibrous protein that provides structural integrity to hair, nails, and the epidermis.
- Option B:** Collagen is a triple-helical fibrous protein providing tensile strength to tendons, ligaments, and skin.
- Option D:** While histones are basic nuclear proteins, hemoglobin is the canonical example of a physiological transport globular protein in standard textbook curricula.

Question #32 Key: (B)BIOLOGY
10. Homeostasis

The process of osmoregulation refers to:

CORE CONCEPT & DERIVATION

Osmoregulation is the active homeostatic maintenance of internal water and solute (osmotic) balance within an organism relative to its surroundings.

Formula / Rule / Reaction:Internal Osmolarity $\approx$ Constant (Balancing Water Gain/Loss and Solute Gain/Loss)**Solution:**

- Organisms continuously gain and lose water and dissolved solutes through metabolic processes, excretion, and environmental exchange.
- Osmoregulation prevents cells from either swelling and bursting in hypotonic environments or shrinking and dehydrating in hypertonic environments.

Why other options are incorrect:

- Option A:** The elimination of metabolic waste products (such as urea and uric acid) describes excretion, not osmoregulation.
- Option C:** Establishing a medullary osmotic gradient via the loop of Henle is a specific physiological mechanism within mammalian kidneys, not the broad definition of osmoregulation.
- Option D:** Hormonal secretion (e.g., aldosterone, ADH) regulates osmoregulatory organs, but it is not the definition of the process itself.

Question #33 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

A baby girl is born with hemophilia, which is an X-linked recessive disorder. What are the most...

CORE CONCEPT & DERIVATION

Hemophilia is an X-linked recessive condition. For a female (XX) to manifest the disorder, she must inherit a mutant allele on both of her X chromosomes (X^hX^h).

Formula / Rule / Reaction:

Mother: $X^H X^h$ (Carrier) × Father: $X^h Y$ (Hemophiliac) → Daughters: 50% $X^H X^h$ (Carrier), 50% $X^h X^h$ (Affected)

Solution:

- The affected daughter must have the genotype X^hX^h .
- She receives one X^h chromosome from her mother and one X^h chromosome from her father.
- Because males have only one X chromosome, the father must be hemophiliac (X^hY).
- The mother must contribute an X^h allele, meaning she must be at least a heterozygous carrier ($X^H X^h$) or affected.

Why other options are incorrect:

- **Option A:** A normal father transmits a dominant X^H allele to all his daughters, making an affected daughter impossible.
- **Option B:** A normal father passes an X^H allele, so all daughters will be phenotypically normal carriers ($X^H X^h$).
- **Option D:** Two phenotypically normal parents can yield carrier or affected sons, but cannot produce an affected X^hX^h daughter.

Question #34 Key: (C)BIOLOGY
01. Cell

Identify the most appropriate function of chromosomes

CORE CONCEPT & DERIVATION

Chromosomes are nuclear nucleoprotein structures consisting of linear DNA molecules wrapped around histone octamers, functioning as the repository of hereditary information.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The nucleotide sequence of chromosomal DNA encodes the genetic instructions for all cellular structural proteins, enzymes, and RNAs.
- Chromosomes package, protect, and accurately transmit this genetic blueprint during cell division and sexual reproduction.

Why other options are incorrect:

- **Option A:** Energy production and ATP synthesis are carried out by mitochondria.
- **Option B:** Protein synthesis occurs on ribosomes in the cytoplasm, while transcription factors regulate expression.
- **Option D:** Lipid synthesis, metabolism, and transport are mediated by the smooth endoplasmic reticulum and Golgi apparatus.

Question #35 Key: (C)BIOLOGY
03. Enzymes

Enzymes belong to which class of biomolecules?

CORE CONCEPT & DERIVATION

Enzymes are specialized biological catalysts that accelerate chemical reactions by lowering the activation energy barrier; virtually all cellular enzymes are globular proteins.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Enzymes are linear polymers of amino acids folded into defined three-dimensional tertiary or quaternary conformations.
- Their active sites are composed of specific catalytic and binding amino acid side chains.
- Hence, enzymes are classified biochemically as proteins.

Why other options are incorrect:

- **Option A:** Carbohydrates function primarily as energy sources (e.g., glucose, starch) and structural elements (e.g., cellulose).
- **Option B:** Lipids function as membrane components, thermal insulators, and energy reserves.
- **Option D:** Nucleic acids (DNA and RNA) store and transfer genetic information (with the rare exception of catalytic ribozymes, true enzymes are proteins).

Question #36 Key: (C)BIOLOGY
02. Biomolecules

_____ arranges the DNA into the chromosomes in a eukaryotic cell

CORE CONCEPT & DERIVATION

Eukaryotic DNA is packaged and ordered inside the nucleus by positively charged basic proteins called histones, forming chromatin fibers.

Formula / Rule / Reaction:

DNA + Histone Octamer → Nucleosome Bead → 30 nm Fiber → Metaphase Chromosome

Solution:

- Positively charged basic amino acids (lysine and arginine) in histone proteins bind electrostatically to the negatively charged phosphodiester backbone of DNA.
- An octamer of core histones (two each of H2A, H2B, H3, and H4) wraps approximately 146 base pairs of DNA to form nucleosomes.
- Histone H1 acts as a linker to pack nucleosomes into higher-order chromosome structures.

Why other options are incorrect:

- **Option A:** Hormones are chemical messengers that regulate physiological and developmental processes across tissues.
- **Option B:** Elastin is a structural fibrous protein of the extracellular matrix providing elastic recoil to tissues.
- **Option D:** The nucleosome is the structural unit formed by the interaction, but the histones are the specific proteins that arrange and package the DNA.

Question #37 Key: (C)BIOLOGY
01. Cell

The function of nucleolus is to make:

CORE CONCEPT & DERIVATION

The nucleolus is a dense, non-membrane-bound subnuclear region responsible for transcribing ribosomal RNA (rRNA) and assembling it into ribosomal subunits.

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

- The nucleolar organizer regions (NORs) of chromosomes transcribe precursor rRNAs.
- These rRNAs are processed and assembled with ribosomal proteins imported from the cytoplasm to produce the large and small ribosomal subunits.
- These subunits are then exported through nuclear pores into the cytoplasm to execute translation.

Why other options are incorrect:

- **Option A:** rDNA refers to genomic chromosomal genes that encode rRNA; it is not synthesized de novo by the nucleolus.
- **Option B:** Lysosomes originate by budding from the Golgi apparatus.
- **Option D:** Chromosomes are duplicated in the nucleoplasm during the S phase of interphase.

Question #38 Key: (B)BIOLOGY
07. Circulation / Transport

Which of the following blood vessels have lowest blood velocity with correct reason for low blood velocity...

CORE CONCEPT & DERIVATION

According to the law of continuity, the velocity of fluid flow through a closed network is inversely proportional to the total cross-sectional area of the vessels.

Formula / Rule / Reaction:

$$v = \frac{Q}{A_{\text{total}}} \implies v \propto \frac{1}{A_{\text{total}}}$$

Solution:

- Although each capillary is microscopic, there are billions of them, giving the capillary bed the largest total cross-sectional area of any vascular segment (over 2000 cm²).
- As a result, blood velocity drops to its lowest value (less than 1 mm/s) in capillaries.
- This slow transit provides adequate time for metabolic diffusion and gas exchange between blood and interstitial fluid.

Why other options are incorrect:

- **Option A:** Arteries have high velocity due to narrow total cross-sectional area and direct ventricular driving pressure.
- **Option C:** Veins have a higher velocity than capillaries because their total cross-sectional area decreases as they converge toward the venae cavae.
- **Option D:** Blood flow through capillaries is strictly unidirectional, not two-way.

Question #39 Key: (B)BIOLOGY
01. Cell

An active athlete has more stamina of running compared to an officer of same age with physical...

CORE CONCEPT & DERIVATION

Endurance exercise training stimulates mitochondrial biogenesis in skeletal muscle fibers, significantly enhancing cellular oxidative phosphorylation capacity.

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

- Mitochondria produce the bulk of cellular ATP through the citric acid cycle and the electron transport chain.
- Regular endurance running demands continuous aerobic ATP production, triggering an increase in the size and number of mitochondria within muscle fibers.
- This biochemical adaptation delays muscular fatigue and increases stamina.

Why other options are incorrect:

- **Option A:** While skeletal muscle fibers are multinucleated, nucleus count does not increase to enhance aerobic capacity.
- **Option C:** Golgi bodies package secretory proteins and do not directly control energy production.
- **Option D:** The smooth ER (sarcoplasmic reticulum) regulates intracellular calcium flux, but its proliferation does not drive aerobic endurance.

Question #40 Key: (C)BIOLOGY
11. Support & Movement

Once an action potential reaches the membrane of a skeletal muscle fiber, what is the first event...

CORE CONCEPT & DERIVATION

Excitation-contraction coupling begins when sarcolemmal depolarization propagates into transverse tubules (T-tubules), triggering calcium release into the sarcoplasm.

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

- Depolarization of the T-tubule membrane activates voltage-sensing dihydropyridine (DHP) receptors.
- This conformational shift opens connected ryanodine receptors on the terminal cisternae of the sarcoplasmic reticulum.
- Stored calcium ions flow down their electrochemical gradient into the sarcoplasm to initiate filament sliding.

Why other options are incorrect:

- **Option A:** Cross-bridge formation occurs downstream after calcium binds to troponin C and moves tropomyosin away from actin active sites.
- **Option B:** Active re-uptake of calcium by SERCA pumps occurs during muscle relaxation.
- **Option D:** ATP is hydrolyzed by the ATPase domain of the myosin globular head, not by troponin.

Question #41 Key: (B)BIOLOGY
11. Support & Movement

The pubic symphysis is a slightly moveable joint joined by which of the following tissue?

CORE CONCEPT & DERIVATION

The pubic symphysis is a secondary cartilaginous joint (symphysis) in the median plane consisting of a fibrocartilaginous disc uniting the pubic bones.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Fibrocartilage contains thick bundles of type I collagen fibers that provide high tensile strength and shock absorption.
- The fibrocartilaginous interpubic disc allows slight movement during locomotion and widens under the influence of relaxin during parturition.

Why other options are incorrect:

- Option A:** Elastic cartilage contains abundant elastin fibers and is found in flexible structures like the external ear and epiglottis.
- Option C:** Costal cartilage consists of hyaline cartilage bars that attach the anterior ends of ribs to the sternum.
- Option D:** Articular cartilage is a layer of hyaline cartilage covering the ends of bones in freely movable synovial joints.

Question #42 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

In a pea plant seed color is determined by one gene, with yellow (dominant) and green (recessive)...

CORE CONCEPT & DERIVATION

A 1 : 1 phenotypic ratio in offspring is the characteristic outcome of a Mendelian test cross between a heterozygous dominant individual and a homozygous recessive individual.

Formula / Rule / Reaction:

$$Yy \times yy \rightarrow \frac{1}{2} Yy \text{ (Yellow)} : \frac{1}{2} yy \text{ (Green)} = 1 : 1$$

Solution:

- The heterozygous parent (Yy) produces two types of gametes in equal proportion: 50% Y and 50% y.
- The homozygous recessive parent (yy) produces only y gametes.
- Fertilization yields 50% Yy (yellow seeds) and 50% yy (green seeds), establishing a 1 : 1 phenotypic ratio.

Why other options are incorrect:

- Option A:** Produces 100% YY (all yellow seeds).
- Option C:** A monohybrid cross of two heterozygotes yields a 3 : 1 phenotypic ratio (3 yellow : 1 green).
- Option D:** Crossing homozygous dominant with homozygous recessive produces 100% Yy (all yellow seeds).

Question #43 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

Mendel crossed a plant with round yellow seeds (RRYY) and was a plant with wrinkled green seeds...

CORE CONCEPT & DERIVATION

In a dihybrid cross between two true-breeding homozygous parents displaying dominant and recessive traits, the entire F₁ generation expresses the dominant phenotypes.

Formula / Rule / Reaction:

$$P_1 : RRY Y \times rryy \rightarrow \text{Gametes: } RY \times ry \rightarrow F_1 : RrYy \text{ (Round, Yellow)}$$

Solution:

- The RRY Y parent produces gametes carrying dominant alleles R and Y.
- The rryy parent produces gametes carrying recessive alleles r and y.
- All F₁ offspring have the dihybrid genotype RrYy, expressing the dominant phenotypes: round seed shape and yellow seed color.

Why other options are incorrect:

- Option A:** Green is a recessive trait and cannot be expressed in the presence of the dominant Y allele in F₁.
- Option C:** Wrinkled is a recessive trait and cannot be expressed in the presence of the dominant R allele in F₁.
- Option D:** Wrinkled green represents the double recessive phenotype, which only appears in a homozygous state (rryy).

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

In normal 28 days menstrual cycle when would you expect the LH surge to occur?

CORE CONCEPT & DERIVATION

In a typical 28-day human ovarian cycle, the luteinizing hormone (LH) surge peaks 24 to 36 hours before ovulation, occurring at mid-cycle.

Formula / Rule / Reaction:

Day 1 → Follicular Phase → LH Surge (Days 11–14) → Ovulation (approx Day 14) →

Solution:

- During days 11 to 14, high estrogen levels from the dominant Graafian follicle exert positive feedback on the pituitary gland.
- This triggers a sharp release of LH (the LH surge), which reaches its peak around day 13 or 14 and induces ovulation on day 14.

Why other options are incorrect:

- Option A:** Days 7 to 10 represent the mid-follicular phase during which follicles are still maturing and estrogen is rising.
- Option C:** Days 15 to 18 mark the early luteal phase following ovulation, characterized by corpus luteum development.
- Option D:** Days 19 to 22 correspond to the mid-luteal phase when progesterone is elevated.

Question #45 Key: (B)BIOLOGY
02. Biomolecules

Which property of water helps in moderating Earth's climate and maintaining stable temperature ...

CORE CONCEPT & DERIVATION

Water has a high specific heat capacity ($4.184 \text{ J} \cdot \text{g}^{-1} \cdot \text{K}^{-1}$) owing to its extensive intermolecular hydrogen-bonding network.

Formula / Rule / Reaction:

$$q = m \cdot c \cdot \Delta T \implies \Delta T = \frac{q}{m \cdot c}$$

Solution:

- A high value of specific heat (c) means that water must absorb or release large quantities of thermal energy (q) for every small change in temperature (ΔT).
- This thermal inertia enables oceans and large water bodies to resist rapid temperature fluctuations, moderating regional climate and stabilizing aquatic habitats.

Why other options are incorrect:

- Option A:** Low viscosity facilitates fluid motion through vessels, but it does not dictate thermal stability.
- Option C:** High surface tension allows small organisms to walk on water surfaces, but it does not control thermal moderation.
- Option D:** High density influences buoyancy and convection currents, but does not provide thermal buffering against ambient heating or cooling.

Question #46 Key: (B)BIOLOGY
03. Enzymes

What is the effect of increased substrate concentration on enzyme activity?

CORE CONCEPT & DERIVATION

At a constant enzyme concentration, raising substrate concentration increases molecular collisions with active sites until all catalytic sites become occupied (saturation).

Formula / Rule / Reaction:

$$v = \frac{V_{\max}[S]}{K_m + [S]} \implies \lim_{[S] \rightarrow \infty} v = V_{\max}$$

Solution:

- At low substrate concentration, many enzyme active sites remain unoccupied, so reaction rate increases proportionally with substrate addition.
- As substrate concentration rises further, active sites become progressively occupied.
- When every active site is continuously engaged in catalysis, the enzyme reaches saturation velocity ($V_{\max}$), after which additional substrate produces no further increase in rate.

Why other options are incorrect:

- Option A:** Substrate addition increases collision frequency; it does not decrease the reaction rate.
- Option C:** Substrate concentration directly affects the rate until saturation is achieved.
- Option D:** The reaction rate does not rise indefinitely in a linear manner because the finite number of enzyme active sites creates a plateau at $V_{\max}$.

Question #47 Key: (A)BIOLOGY
02. Biomolecules

An oligosaccharide is made up of at least:

CORE CONCEPT & DERIVATION

Oligosaccharides are carbohydrates that yield 2 to 10 monosaccharide units upon complete acid or enzymatic hydrolysis.

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

- The simplest oligosaccharides are disaccharides (e.g., maltose, sucrose, lactose), which consist of exactly two monosaccharide units joined by a glycosidic bond.
- Therefore, the minimum number of saccharide units required to form an oligosaccharide is two.

Why other options are incorrect:

- Option B:** Ten saccharide units represents the upper boundary of the oligosaccharide classification, not its minimum requirement.
- Option C:** Three saccharide units describes trisaccharides; excluding disaccharides (two units) violates the biochemical definition.
- Option D:** Carbohydrates containing more than ten monosaccharide units are classified as polysaccharides.

Question #48 Key: (A)BIOLOGY
08. Immunity

Which statement best explains the difference between humoral and cell mediated immune responses...

CORE CONCEPT & DERIVATION

Adaptive immunity comprises two arms: humoral immunity, mediated by B-cell-derived antibodies in body fluids, and cell-mediated immunity, mediated by cytotoxic and helper T-cells acting on infected host cells.

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

- Humoral immunity relies on B-lymphocytes differentiating into plasma cells that secrete circulating antibodies targeting extracellular pathogens and toxins.
- Cell-mediated immunity relies on T-lymphocytes (CD8+ cytotoxic T-cells and CD4+ helper T-cells) that recognize and eliminate intracellular pathogens, infected cells, and foreign tissue grafts.

Why other options are incorrect:

- Option B:** Both branches defend against both bacteria and viruses depending on whether the pathogen is located in extracellular fluid or within infected host cells.
- Option C:** Both humoral and cell-mediated immunity are highly antigen-specific components of the adaptive immune system.
- Option D:** Cell-mediated immunity relies entirely on immune cells (T-lymphocytes, macrophages, and dendritic cells).

Question #49 Key: (A)BIOLOGY
01. Cell

Which of the following is the correct higher (left) to lower (right) sequence of molecules with...

CORE CONCEPT & DERIVATION

According to cellular chemical composition tables in standard textbooks (Punjab Textbook Board Biology, Table 2.1), total cellular DNA exceeds total RNA fraction amounts in mammalian cells, and ribosomal RNA is the predominant RNA species.

Formula / Rule / Reaction:

RNA Abundance Breakdown: rRNA ($\approx 80\%$) > tRNA ($\approx 15\%$) > mRNA ($\approx 3\text{--}5\%$)

Solution:

- Within a diploid mammalian cell, the stable genomic DNA content forms a substantial baseline nucleic acid mass.
- Among RNA classes, ribosomal RNA (rRNA) constitutes approximately 80 percent of total cellular RNA.
- Transfer RNA (tRNA) constitutes approximately 15 percent of total RNA.
- Messenger RNA (mRNA) is the least abundant and most transient fraction, representing only 3 to 5 percent of total cellular RNA.
- Hence, the descending sequence of abundance is DNA $\rightarrow$ rRNA $\rightarrow$ tRNA $\rightarrow$ mRNA.

Why other options are incorrect:

- **Option B:** Inverts the ranking by placing genomic DNA at the very end of abundance.
- **Option C:** Places mRNA, which is the least abundant RNA class, as the highest in concentration.
- **Option D:** Places mRNA ahead of both tRNA and rRNA, contradicting established cellular composition data.

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

A person in hot weather is unable to maintain body temperature. Which physiological response ha...

CORE CONCEPT & DERIVATION

Thermoregulatory heat-dissipation mechanisms in hot environments rely on autonomic cutaneous vasodilation to increase radiative heat loss and eccrine sweating to facilitate evaporative cooling.

Formula / Rule / Reaction:

$\uparrow T_{\text{core}} \xrightarrow{\text{Anterior Hypothalamus}} \text{Cutaneous Vasodilation} + \text{Eccrine Sweating} \rightarrow \text{Heat Dissipation}$

Solution:

- When ambient temperature exceeds core body temperature, evaporation of sweat is the primary physiological mechanism for cooling the body.
- Arteriolar vasodilation in the dermis brings warm blood close to the skin surface to radiate heat outward.
- Failure of vasodilation and sweating prevents adequate heat dissipation, resulting in hyperthermia and heat stroke.

Why other options are incorrect:

- **Option B:** Vasoconstriction reduces blood flow to the skin to conserve heat during cold exposure; activating it in hot weather would exacerbate overheating.
- **Option C:** Shivering generates metabolic heat during hypothermia; it is inhibited during hot conditions.
- **Option D:** Renin secretion responds to renal hypotension and hypovolemia, not primary thermal regulation.

Question #51 Key: (D)BIOLOGY
16. Evolution

The main idea in Darwin's Theory of "Origin of species by natural selection" is:

CORE CONCEPT & DERIVATION

Darwinian evolutionary theory asserts that organisms possessing heritable variations suited to their environment enjoy differential reproductive success, leading to gradual adaptive changes in populations over time.

Formula / Rule / Reaction:

Overproduction + Heritable Variation + Differential Survival $\rightarrow$ Gradual Accumulation of A

Solution:

- Populations naturally produce more offspring than environmental resources can sustain, creating a struggle for existence.
- Individuals carrying advantageous variations have a higher probability of surviving and reproducing.
- Over successive generations, natural selection preserves these favorable traits, resulting in gradual evolution and the origin of new species.

Why other options are incorrect:

- **Option A:** Inheritance of acquired traits is the central postulate of Lamarckism, which was rejected by Darwinian genetics.
- **Option B:** The principle of use and disuse of organs is another Lamarckian premise.
- **Option C:** Darwin demonstrated that species are dynamic and undergo evolutionary change, directly opposing the doctrine of species fixity.

Question #52 Key: (C)BIOLOGY
02. Biomolecules

Which of the following is a key feature of RNA?

CORE CONCEPT & DERIVATION

Ribonucleic acid (RNA) is biochemically distinguished from deoxyribonucleic acid (DNA) by its pentose sugar moiety and pyrimidine base composition.

Formula / Rule / Reaction:

$$\text{RNA Nucleotide} = \text{Ribose (contains 2'-OH)} + \text{Phosphate} + \text{Base (A, U, G, C)}$$
Solution:

- RNA contains a β -D-ribose sugar that possesses a hydroxyl group ($-\text{OH}$) on the 2'-carbon atom.
- In RNA, the pyrimidine base uracil replaces thymine (5-methyluracil) and forms complementary base pairs with adenine.

Why other options are incorrect:

- **Option A:** Deoxyribose sugar and thymine are defining chemical hallmarks of DNA.
- **Option B:** Genomic RNA is predominantly single-stranded, and thymine is absent from standard cellular RNA.
- **Option D:** Thymine is not found in standard RNA; uracil is present instead.

Question #53 Key: (B)BIOLOGY
01. Cell

Which of the following types of RNA makes up the largest proportion of total cellular RNA?

CORE CONCEPT & DERIVATION

Ribosomal RNA (rRNA) is the structural and catalytic framework of ribosomes and constitutes the vast majority of total RNA content in living cells.

Formula / Rule / Reaction:

Cellular RNA Distribution: rRNA ($\approx 80\%$) > tRNA ($\approx 15\%$) > mRNA ($\approx 3-5\%$) > snRNA/Ribozymes ($< 1\%$)

Blood Plasma $\xrightarrow{\text{Capillary Filtration}}$ Interstitial Fluid $\xrightarrow{\text{Lymphatic Uptake}}$ Lymph

Solution:

- Ribosomes are present by the millions in actively growing metabolic cells.
- Because rRNA provides the structural architecture and catalytic peptidyl-transferase activity for protein synthesis, it accounts for approximately 80 percent of the total cellular RNA mass.

Why other options are incorrect:

- **Option A:** Messenger RNA is synthesized on demand and turned over rapidly, accounting for only 3 to 5 percent of cellular RNA.
- **Option C:** Transfer RNA accounts for approximately 10 to 15 percent of total RNA.
- **Option D:** Specialized catalytic RNAs and ribozymes make up less than 1 percent of total cellular RNA.

Question #54 Key: (A)BIOLOGY
14. ReproductionThe bacterium *Treponema Pallidum* is responsible for which sexually transmitted disease?**CORE CONCEPT & DERIVATION**

Treponema pallidum is a microaerophilic, motile spirochete bacterium that acts as the obligate human pathogen responsible for syphilis.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Syphilis is a multistage sexually transmitted infection characterized sequentially by primary hard chancres, secondary mucocutaneous lesions, latent periods, and tertiary gummatous or neurosyphilitic damage.
- Microscopic darkfield examination identifies the corkscrew-shaped spirochete *Treponema pallidum* as the causative agent.

Why other options are incorrect:

- **Option B:** Chlamydia is caused by the obligate intracellular bacterium *Chlamydia trachomatis*.
- **Option C:** Gonorrhea is caused by the Gram-negative diplococcus *Neisseria gonorrhoeae*.
- **Option D:** Genital herpes is caused by Herpes Simplex Virus type 2 (HSV-2).

Question #55 Key: (C)BIOLOGY
07. Circulation / Transport

Tissue fluid in a lymphatic system is called as:

CORE CONCEPT & DERIVATION

Interstitial fluid that diffuses across the porous endothelial lining of blind-ended lymphatic capillaries is formally termed lymph.

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

- At systemic capillary beds, fluid filters out into the extracellular tissue spaces, forming interstitial fluid.
- When this clear, watery fluid enters the specialized vessels of the lymphatic drainage system, it is referred to as lymph.
- Lymph contains electrolytes, absorbed dietary lipids, and lymphocytes as it flows toward the thoracic and lymphatic ducts.

Why other options are incorrect:

- **Option A:** Plasma is the liquid extracellular matrix of blood confined within blood vessels.
- **Option B:** Matrix refers to the acellular structural ground substance of connective tissues.
- **Option D:** Blood is the primary circulatory fluid containing erythrocytes, leukocytes, and platelets confined to the cardiovascular system.

Question #56 Key: (D)BIOLOGY
02. Biomolecules

Which one of the following biomolecules is a polymer/polysaccharide?

CORE CONCEPT & DERIVATION

Polysaccharides are high-molecular-weight polymers composed of hundreds to thousands of repeating monosaccharide subunits joined by glycosidic bonds.

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

- Glycogen is a highly branched homopolysaccharide of α -D-glucose serving as the primary carbohydrate storage macromolecule in animals and fungi.
- Because it consists of extensive repeating monomeric units, it is a macromolecular polymer.

Why other options are incorrect:

- Option A:** Sucrose is a disaccharide consisting of one glucose and one fructose molecule (two units).
- Option B:** Pentose is a five-carbon monosaccharide (single sugar unit, such as ribose).
- Option C:** Lactose is a disaccharide composed of one glucose and one galactose unit.

Question #57 Key: (D)BIOLOGY
12. Nervous Coordination

Olfactory receptors are the type of:

CORE CONCEPT & DERIVATION

Chemoreceptors are specialized sensory receptor cells that detect specific dissolved chemical ligands and transduce them into electrochemical signals.

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

- Olfactory receptor neurons reside within the olfactory neuroepithelium in the superior nasal cavity.
- Their cilia contain G-protein coupled receptors that bind airborne odorant chemical compounds dissolved in nasal mucus.
- Because they transduce chemical stimuli, they are classified as chemoreceptors.

Why other options are incorrect:

- Option A:** Photoreceptors (rods and cones in the retina) transduce electromagnetic light energy.
- Option B:** Mechanoreceptors respond to mechanical deformation such as touch, pressure, vibration, and stretch.
- Option C:** Thermoreceptors detect fluctuations in temperature.

Question #58 Key: (C)BIOLOGY
10. Homeostasis

Which of the following organisms eliminate nitrogenous waste mainly in the form of uric acid?

CORE CONCEPT & DERIVATION

Uricotelic organisms convert toxic ammonia into insoluble, non-toxic uric acid to conserve water, which is particularly beneficial for flight and cleidoic (shelled) egg development.

Formula / Rule / Reaction:Uricotelism: Excretion of Uric Acid ($C_5H_4N_4O_3$) as a Semi-solid Paste requiring Minimal Water**Solution:**

- Birds (as well as terrestrial reptiles and insects) excrete nitrogenous wastes primarily as uric acid paste.
- Because uric acid is insoluble in water and precipitates out of solution, it requires very little water for excretion (approximately 1 mL of water per gram of nitrogen), conserving water in terrestrial habitats.

Why other options are incorrect:

- Option A:** Freshwater fish are ammonotelic; they excrete highly soluble and toxic ammonia directly across their gills into the surrounding water.
- Option B:** Adult amphibians are ureotelic, excreting nitrogenous waste primarily as urea.
- Option D:** Mammals are ureotelic; the liver synthesizes water-soluble urea via the ornithine urea cycle for renal excretion.

Question #59 Key: (A)BIOLOGY
12. Nervous Coordination

Which of the following cells possess Nissl's granules?

CORE CONCEPT & DERIVATION

Nissl's granules (Nissl bodies) are specialized basophilic structures composed of aggregated rough endoplasmic reticulum and polyribosomes found in the cytoplasm of neurons.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Nissl's granules are found specifically in the perikaryon (soma) and primary dendrites of nerve cells (neurons).
- They synthesize proteins and neurotransmitter precursor peptides required for axonal maintenance and synaptic transmission.

Why other options are incorrect:

- Option B:** White blood cells contain standard rough ER and lysosomes (azurophilic granules), but do not contain Nissl's granules.
- Option C:** Mature human erythrocytes (RBCs) lack nuclei, ribosomes, and endoplasmic reticulum entirely.
- Option D:** Platelets are anucleate cytoplasmic fragments of megakaryocytes containing alpha and dense granules, but no Nissl bodies.

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

Which part of human brain is involved in maintaining the posture and balance of the body?

CORE CONCEPT & DERIVATION

The cerebellum processes vestibular, proprioceptive, and visual sensory feedback to coordinate voluntary motor outputs and maintain balance and upright posture.

Formula / Rule / Reaction:

Vestibular/Proprioceptive Inputs $\xrightarrow{\text{Cerebellum}}$ Fine-Tuned Motor Output to Skeletal Muscles $\rightarrow$ Equilibrium

Pubic Symphysis = Amphiarthrosis (Cartilaginous Joint connected by Fibrocartilage Discs)

Solution:

- The cerebellum receives continuous sensory input from the semicircular canals of the inner ear, muscle spindles, and joint receptors.
- It rapidly calculates corrections for postural sway and coordinates antagonistic muscle groups to maintain balance and smooth motor execution.

Why other options are incorrect:

- **Option A:** The cerebrum initiates conscious voluntary motor commands and higher cognitive functions.
- **Option C:** The hypothalamus serves as the primary neuroendocrine and visceral homeostatic coordinator (temperature, thirst, hunger).
- **Option D:** The medulla oblongata regulates involuntary cardiorespiratory and gastrointestinal reflexes.

Question #61 Key: (A)BIOLOGY
11. Support & Movement

Arthritis is:

CORE CONCEPT & DERIVATION

Arthritis is a general clinical term derived from the Greek 'arthro-' (joint) and '-itis' (inflammation), denoting acute or chronic inflammatory disease of one or more joints.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Pathophysiologically, arthritis involves inflammation of the synovial membrane, articular cartilage breakdown, and periarticular bone remodeling.
- Common variants include osteoarthritis (degenerative joint disease) and rheumatoid arthritis (autoimmune synovitis), both characterized by joint pain, swelling, and reduced range of motion.

Why other options are incorrect:

- **Option B:** Infection of the intervertebral disc is termed discitis (or spondylodiscitis).
- **Option C:** Pathological fusion and stiffening of vertebral joints is termed ankylosis (such as in ankylosing spondylitis).
- **Option D:** Radiating tingling or numbness along the path of the sciatic nerve down the leg is termed sciatica.

Question #62 Key: (C)BIOLOGY
11. Support & Movement

Which type of joint is present in pubis?

CORE CONCEPT & DERIVATION

The two pubic bones articulate at the anterior midline via the pubic symphysis, which is structurally classified as a secondary cartilaginous joint.

Formula / Rule / Reaction:

Pubic Symphysis = Amphiarthrosis (Cartilaginous Joint connected by Fibrocartilage Discs)

Solution:

- The pubic symphysis consists of an intervening pad of fibrocartilage reinforced by superior and arcuate pubic ligaments.
- It is classified functionally as an amphiarthrosis (slightly movable joint) and structurally as a cartilaginous joint.

Why other options are incorrect:

- **Option A:** Fibrous joints (e.g., cranial sutures, syndesmoses) are bound directly by dense fibrous connective tissue without intervening cartilage.
- **Option B:** Immovable joints (synarthroses) permit no functional motion; the pubic symphysis allows limited movement, especially during childbirth.
- **Option D:** Freely movable joints are synovial joints characterized by a fluid-filled joint cavity and synovial capsule.

Question #63 Key: (A)BIOLOGY
12. Nervous Coordination

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

CORE CONCEPT & DERIVATION

Motor (efferent) neurons transmit action potentials from the central nervous system to peripheral effector organs, exciting neuromuscular junctions to trigger muscle contraction.

Formula / Rule / Reaction:

Ventral Horn Motor Neuron $\xrightarrow{\text{Acetylcholine Release at Motor End Plate}}$ Muscle Fiber Contraction

Solution:

- The cell bodies of somatic motor neurons reside in the ventral gray horn of the spinal cord.
- Their axons exit through the ventral roots and terminate on skeletal muscle fibers at motor end plates.
- Release of acetylcholine initiates depolarization of the sarcolemma, causing the muscle to contract.

Why other options are incorrect:

- **Option B:** Sensory (afferent) neurons transmit sensory information from peripheral receptors toward the central nervous system.
- **Option C:** Interneurons (associative neurons) integrate signals locally within the central nervous system and do not directly innervate muscle fibers.
- **Option D:** Relay neurons are synonymous with interneurons and remain confined within the spinal cord gray matter.

Question #64 Key: (C)BIOLOGY
01. Cell

Which of the following statements best compares cell division in prokaryotic and Eukaryotic cel...

CORE CONCEPT & DERIVATION

Prokaryotic cells lack a nucleus and mitotic spindle apparatus, reproducing asexually via binary fission, whereas eukaryotic somatic cells divide via the organized stages of mitosis.

Formula / Rule / Reaction:

Prokaryotes: Direct Binary Fission vs. Eukaryotes: Mitotic Spindle-Driven Mitosis

Solution:

- Prokaryotes replicate their single circular chromosome, attach the origins to the plasma membrane, elongate, and divide via an FtsZ ring in binary fission.
- Eukaryotes possess multiple linear chromosomes that undergo chromatin condensation, nuclear envelope breakdown, spindle assembly, and strict checkpoint-regulated chromatid segregation during mitosis.

Why other options are incorrect:

- Option A:** Eukaryotes primarily divide by mitosis, and prokaryotes cannot undergo mitosis because they lack a spindle apparatus and nuclear membrane.
- Option B:** Binary fission is characteristic of prokaryotes, whereas meiosis is an exclusive eukaryotic reduction division used for gamete production.
- Option D:** Mitosis requires microtubules, centrioles/centrosomes, and a mitotic spindle, which prokaryotic cells do not possess.

Question #65 Key: (C)BIOLOGY
16. Evolution

Which of the following best describes "acquired characteristics" according to Lamarckism?

CORE CONCEPT & DERIVATION

Jean-Baptiste Lamarck's evolutionary hypothesis proposed that modifications developed by an individual during its lifetime through the use or disuse of parts are inherited by its offspring.

Formula / Rule / Reaction:

Environmental Demand → Use/Disuse of Organ → Somatic Modification → Inheritance by Offspring

Solution:

- According to Lamarck, frequent and sustained use of an organ strengthens and enlarges it, while permanent disuse leads to its atrophy and disappearance.
- Lamarck claimed that these acquired somatic alterations could be passed directly to the next generation (inheritance of acquired characteristics).

Why other options are incorrect:

- Option A:** Mutations are sudden, random alterations in DNA sequences, a concept introduced by Hugo de Vries, not Lamarck.
- Option B:** Traits inherited directly from parental germ cells represent innate genetic inheritance.
- Option D:** Environmental selection of preexisting heritable traits is the core mechanism of Darwin's natural selection.

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

According to Lock and Key model, the active site is regarded as:

CORE CONCEPT & DERIVATION

Emil Fischer's Lock and Key model (1894) posits that an enzyme's active site possesses a preformed, rigid, and complementary three-dimensional geometry that precisely fits its specific substrate.

Formula / Rule / Reaction:

Substrate (Key) + Rigid Active Site (Lock) $\rightleftharpoons$ Enzyme-Substrate Complex

Solution:

- The Lock and Key model assumes that no conformational adjustments occur in the enzyme upon substrate binding.
- The active site is treated as an inflexible (rigid) template that accommodates only one specific substrate possessing complementary shape and chemical features.

Why other options are incorrect:

- Option B:** A flexible and specific active site defines Daniel Koshland's Induced Fit model, not the Lock and Key model.
- Option C:** The active site in the Lock and Key model is highly specific for its particular substrate.
- Option D:** Neither model regards the active site as nonspecific; enzymes are characteristically substrate-specific.

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

Peptide bonds are important in protein because they:

CORE CONCEPT & DERIVATION

Peptide bonds are covalent amide linkages formed between the α -carboxyl group of one amino acid and the α -amino group of an adjacent amino acid, creating the primary backbone of proteins.

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

- The primary structure of a protein is defined by its linear sequence of amino acids.
- Peptide bonds covalently join successive amino acid residues into a continuous polypeptide chain.
- Without peptide bonds, individual amino acids could not assemble into functional polypeptide chains.

Why other options are incorrect:

- Option A:** Protein solubility is determined primarily by the chemical nature of surface-exposed amino acid R-groups and hydration shells, not directly by the peptide bonds.
- Option B:** R-groups are covalently bonded to the α -carbon atoms of individual amino acids, not held by the peptide bond itself.
- Option D:** Releasing oxygen is a function of allosteric interactions within heme groups in proteins like hemoglobin.

Question #68 Key: (D)BIOLOGY
05. Acellular Life

Why are retroviruses placed in a separate class of RNA viruses?

CORE CONCEPT & DERIVATION

Retroviruses are unique among RNA viruses because they carry the enzyme reverse transcriptase (RNA-dependent DNA polymerase) to reverse the normal flow of genetic transcription.

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

- Standard positive-sense RNA viruses either translate directly into protein or replicate via RNA-dependent RNA polymerase.
- Retroviruses transcribe their single-stranded RNA genome into complementary double-stranded DNA inside the host cell.
- This viral DNA is then permanently integrated into the host genome as a provirus, a replication strategy unique to this viral family.

Why other options are incorrect:

- Option A:** Many other RNA virus families infect animal cells (e.g., orthomyxoviruses, paramyxoviruses, coronaviruses); host range does not define retroviruses.
- Option B:** Positive-sense single-stranded RNA viruses (like picornaviruses) have genomes that act directly as mRNA, whereas retroviral RNA undergoes reverse transcription first.
- Option C:** Retroviruses possess a protein capsid and a lipoprotein envelope; they do not lack protein coats.

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

Reversible inhibitors differ from irreversible inhibitors because they:

CORE CONCEPT & DERIVATION

Reversible enzyme inhibitors associate with enzymes through non-covalent interactions (hydrogen bonds, ionic bonds, hydrophobic interactions) that can readily dissociate.

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

- Reversible inhibitors establish a dynamic equilibrium between free enzyme and the enzyme-inhibitor complex.
- Because binding is non-covalent, the inhibitor can dissociate, or be outcompeted (in competitive inhibition by increasing substrate concentration), restoring full catalytic activity.
- In contrast, irreversible inhibitors form stable covalent bonds that permanently inactivate the enzyme.

Why other options are incorrect:

- Option A:** Permanent binding via covalent bonds is the defining characteristic of irreversible inhibitors.
- Option C:** Irreversible inhibitors cause permanent inactivation, whereas reversible inhibition can be undone.
- Option D:** Irreversible inhibitors permanently alter active site residues, while reversible inhibitors cause transient, reversible effects.

Question #70 Key: (C)BIOLOGY
06. Digestion/Nutrition

Which is an enzyme activator secreted by the intestinal glands?

CORE CONCEPT & DERIVATION

Enterokinase (enteropeptidase) is a regulatory brush-border enzyme secreted by the duodenal mucosa that converts inactive pancreatic zymogens into active digestive enzymes.

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

- Pancreatic proteases are secreted as inactive proenzymes to prevent autodigestion of the pancreas.
- Enterokinase in the intestinal mucosa cleaves a specific peptide bond in trypsinogen, yielding active trypsin.
- Active trypsin then autocatalytically activates chymotrypsinogen, procarboxypeptidase, and additional trypsinogen molecules.

Why other options are incorrect:

- Option A:** Amylase is a digestive enzyme that hydrolyzes starch into maltose, not an enzyme activator.
- Option B:** Pepsinogen is an inactive zymogen secreted by the chief cells of the gastric mucosa, not the intestine.
- Option D:** Lipase is an enzyme that digests triglycerides into fatty acids and glycerol.

Question #71 Key: (D)BIOLOGY
11. Support & Movement

In which of the following combination, both components have Hyaline cartilage?

CORE CONCEPT & DERIVATION

Hyaline cartilage is the most abundant type of cartilage in the human body, characterized by a glassy, translucent extracellular matrix with fine type II collagen fibrils.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The skeletal framework of the external nose (lateral and alar cartilages, nasal septum) consists of hyaline cartilage.
- The C-shaped cartilaginous rings of the trachea are composed of hyaline cartilage, preventing airway collapse during respiration.
- Therefore, both the nose and the trachea are supported by hyaline cartilage.

Why other options are incorrect:

- Option A:** The epiglottis consists of elastic cartilage, and intervertebral discs consist of fibrocartilage.
- Option B:** While the trachea contains hyaline cartilage, intervertebral discs are made of fibrocartilage.
- Option C:** While the nose contains hyaline cartilage, the pinna (external ear) is composed of elastic cartilage.

Question #72 Key: (D)BIOLOGY
16. Evolution

According to Lamarck, the evolution of long necks in giraffes is explained by:

CORE CONCEPT & DERIVATION

Lamarck used the giraffe as a classic illustration of his theory of the inheritance of acquired characteristics driven by continuous physiological use.

Formula / Rule / Reaction:

Browsing Higher Foliage → Continuous Stretching of Neck → Elongation Passed to Progeny

Solution:

- Lamarck argued that ancestral giraffes had short necks and fed on low vegetation.
- As ground forage became scarce, they continually stretched their necks upward to browse leaves on tall trees.
- This continuous muscular stretching elongated the neck slightly within an individual's lifetime, and this acquired trait was passed to offspring across successive generations.

Why other options are incorrect:

- Option A:** Natural selection is Charles Darwin's mechanism, which proposes that giraffes with naturally longer necks had higher survival rates during droughts.
- Option B:** Genetic mutations were unknown in Lamarck's era; classical Lamarckism did not involve molecular genetics.
- Option C:** Survival of the fittest is an expression coined by Herbert Spencer and incorporated into Darwinian natural selection.

Question #73 Key: (A)BIOLOGY
14. Reproduction

The process of spermatogenesis occurs in which part of the male reproductive system?

CORE CONCEPT & DERIVATION

Spermatogenesis is the biological process by which primordial germ cells (spermatogonia) develop into mature haploid spermatozoa within the testes.

Formula / Rule / Reaction:

Spermatogonium ($2n$) → Primary Spermatocyte → 2 Secondary Spermatocytes → 4 Spermatids → 4 Spermatozoa

Solution:

- The testicular parenchyma is packed with tightly coiled seminiferous tubules.
- Spermatogenesis takes place along the stratified germinal epithelium of these tubules, supported and nourished by Sertoli cells.
- Spermatozoa are released into the lumen of the seminiferous tubules and transported to the epididymis for maturation.

Why other options are incorrect:

- Option B:** The vas deferens (ductus deferens) is a muscular tube that transports mature sperm from the epididymis to the ejaculatory duct.
- Option C:** The scrotum is the external cutaneous sac that suspends the testes outside the abdominal cavity to maintain a cooler temperature for spermatogenesis.
- Option D:** The epididymis is a coiled duct system on the posterior testis where spermatozoa undergo physiological maturation and acquire motility.

Question #74 Key: (C)BIOLOGY
14. Reproduction

Which layer of uterus nourishes the embryo after implantation?

CORE CONCEPT & DERIVATION

The endometrium is the vascular, glandular inner mucosal lining of the uterus that undergoes cyclical proliferation to provide a receptive bed and nutritional support for the implanting blastocyst.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Following fertilization, the blastocyst embeds into the functional layer (stratum functionale) of the endometrium.
- Trophoblastic cells invade the vascular endometrial stroma and uterine glands, establishing the primitive maternal-fetal exchange.
- The endometrium differentiates into the maternal component of the placenta (decidua), supplying oxygen and nutrients to the growing embryo.

Why other options are incorrect:

- Option A:** The cervical epithelium lines the lower anatomical canal of the uterus and produces cervical mucus, but does not participate in embryo implantation or nourishment.
- Option B:** The myometrium is the thick middle muscular layer responsible for uterine contractions during labor.
- Option D:** The perimetrium is the outer serous peritoneal covering that lines the external surface of the uterus.

Question #75 Key: (A)BIOLOGY
01. Cell

The main role of mRNA during protein synthesis is to:

CORE CONCEPT & DERIVATION

Messenger RNA (mRNA) functions as the informational intermediary in the central dogma, carrying genetic instructions from nuclear DNA to cytoplasmic ribosomes.

Formula / Rule / Reaction:

DNA (Gene) $\xrightarrow{\text{Transcription}}$ mRNA $\xrightarrow{\text{Translation}}$ Polypeptide (Protein)

Solution:

- During transcription, RNA polymerase synthesizes an mRNA copy complementary to the DNA template strand.
- The linear sequence of ribonucleotide codons on the mRNA directs the precise order of amino acids assembled into the growing polypeptide chain on ribosomes.

Why other options are incorrect:

- Option B:** Ribosomal RNA (rRNA), in association with ribosomal proteins, stabilizes the ribosome structure.
- Option C:** Transfer RNA (tRNA) molecules carry and deliver specific amino acids to the ribosomal A-site.
- Option D:** The ribosome itself provides the physical platform for translation.

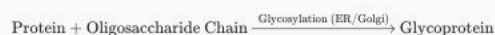
Question #76 Key: (B)BIOLOGY
01. Cell

Glycoproteins are formed as a result of the combination of:

CORE CONCEPT & DERIVATION

Glycoproteins are conjugated proteins in which branched carbohydrate oligosaccharide chains are covalently attached to polypeptide side chains via glycosylation.

Formula / Rule / Reaction:



Solution:

- During post-translational modification in the rough endoplasmic reticulum and Golgi apparatus, sugars are enzymatically linked to asparagine (N-linked) or serine/threonine (O-linked) residues.
- These carbohydrate-protein conjugates play essential roles as cell-surface receptors, extracellular matrix components, and circulating antibodies.

Why other options are incorrect:

- Option A:** Combinations of lipids and proteins are termed lipoproteins (such as HDL, LDL, and chylomicrons).
- Option C:** Complexes of nucleic acids and proteins are termed nucleoproteins (such as chromatin and ribosomes).
- Option D:** Combinations of carbohydrates and lipids are termed glycolipids.

Question #77 Key: (C)BIOLOGY
01. Cell

A student observed a boundary in both plant and animal cells that controls entry and exit of substances...

CORE CONCEPT & DERIVATION

The plasma membrane (cell membrane) is a selectively permeable phospholipid bilayer embedded with proteins that encloses the cytoplasm in all living cells, regulating transport into and out of the cell.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Both plant and animal cells possess a plasma membrane as their living boundary.
- Its amphipathic phospholipid bilayer and selective transport proteins (channels, carriers, pumps) regulate the passage of ions, water, and organic molecules into and out of the cell.

Why other options are incorrect:

- Option A:** Mitochondria are internal energy-generating organelles, not the outer boundary of the cell.
- Option B:** The Golgi apparatus is an internal endomembrane organelle that modifies and packages proteins.
- Option D:** The cell wall is a rigid external layer found in plant, fungal, and bacterial cells, but is absent in animal cells.

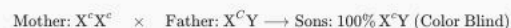
Question #78 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics

If a normal person marries with colour blind female what will be the possibility of normal male...

CORE CONCEPT & DERIVATION

Red-green color blindness is an X-linked recessive disorder. A male receives his single X chromosome from his mother and his Y chromosome from his father.

Formula / Rule / Reaction:



Solution:

- The mother is color blind, so her genotype must be homozygous recessive: X^cX^c .
- Every male child inherits a Y chromosome from the father and an X^c chromosome from the mother.
- Because the mother can only pass an X^c allele, all sons will have the genotype X^cY and will be color blind.
- Therefore, the probability of having a phenotypically normal male child is 0 percent.

Why other options are incorrect:

- Option B:** 25 percent would incorrectly suggest that three-quarters of sons inherit a normal allele from a mother who has none.
- Option C:** 50 percent applies when the mother is a heterozygous carrier (X^CX^c), not when she is homozygous affected.
- Option D:** 75 percent does not match any valid Mendelian ratio for an X-linked recessive cross.

Question #79 Key: (A)BIOLOGY
11. Support & Movement

Which of the following characters is shared by both skeletal and cardiac muscles?

CORE CONCEPT & DERIVATION

Striated muscle tissue is characterized by repeating structural units called sarcomeres, where overlapping actin and myosin filaments produce alternating light and dark bands under microscopy.

Formula / Rule / Reaction:



Solution:

- Both skeletal muscle fibers and cardiac muscle fibers contain highly organized myofibrils divided into sarcomeres.
- This regular arrangement of thick (myosin) and thin (actin) filaments generates alternating dark (A) and light (I) bands, giving both tissue types their characteristic striated microscopic appearance.

Why other options are incorrect:

- Option B:** Involuntary control characterizes cardiac and smooth muscles; skeletal muscle is under voluntary somatic motor control.
- Option C:** Skeletal muscle fibers are true syncytia containing hundreds of peripheral nuclei; cardiac muscle cells typically have only one (or two) centrally located nuclei.
- Option D:** Intercalated discs with gap junctions and desmosomes are unique to cardiac muscle.

Question #80 Key: (C)

BIOLOGY
11. Support & Movement

Which of the following muscle types are involuntary in action?

CORE CONCEPT & DERIVATION

Muscle tissue is classified physiologically into voluntary muscle, which is under conscious somatic control, and involuntary muscle, which contracts automatically under autonomic nervous and hormonal regulation.

Formula / Rule / Reaction:

Autonomic Control $\rightarrow$ Cardiac Muscle (Heart) + Smooth Muscle (Viscera/Vessels) = Involuntary

Solution:

- Cardiac muscle contractions are initiated automatically by intrinsic pacemaker cells and modulated by the autonomic nervous system.
- Smooth muscle lines hollow internal organs (e.g., gut, bladder, arterioles) and is likewise regulated involuntarily by autonomic nerves, hormones, and local metabolic factors.
- Skeletal muscle is consciously controlled by the somatic nervous system.

Why other options are incorrect:

- Option A:** Skeletal muscle is voluntary, so this grouping is incorrect.
- Option B:** Skeletal muscle is voluntary, making this pairing incorrect as well.
- Option D:** Smooth muscle is involuntary, but this choice is incomplete because it omits cardiac muscle.

Question #81 Key: (B)

BIOLOGY
11. Support & Movement

In which of the following combinations, both components have non-striated muscle fibers?

CORE CONCEPT & DERIVATION

Non-striated (smooth) muscle fibers lack regular sarcomeric banding and are found in the muscular tunics of hollow visceral organs and blood vessel walls.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The muscularis externa of the small and large intestines consists of smooth, non-striated muscle that produces peristaltic contractions.
- The tunica media of blood vessels (arteries, arterioles, veins) consists of non-striated vascular smooth muscle that regulates vascular tone and blood pressure.
- Therefore, both the intestine and blood vessels contain non-striated muscle fibers.

Why other options are incorrect:

- Option A:** The biceps brachii is composed of voluntary striated skeletal muscle.
- Option C:** The myocardium of the heart is composed of striated cardiac muscle.
- Option D:** Although the stomach consists of smooth muscle, the heart is composed of striated cardiac muscle.

Question #82 Key: (A)

CHEMISTRY
04. GasesValue of R gas constant in [Formula] is:

CORE CONCEPT & DERIVATION

The universal gas constant (R) is the fundamental physical proportionality constant in the ideal gas equation, relating energy per mole per kelvin in standard SI units.

Formula / Rule / Reaction:

$$R = \frac{PV}{nT} = \frac{(101325 \text{ Pa})(0.022414 \text{ m}^3)}{(1 \text{ mol})(273.15 \text{ K})} = 8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$$

Solution:

- Pressure in SI units is measured in pascals ($1 \text{ Pa} = 1 \text{ N} \cdot \text{m}^{-2}$), and volume is in cubic meters (m^3).
- Because $1 \text{ Pa} \cdot \text{m}^3 = 1 \text{ N} \cdot \text{m} = 1 \text{ J}$, the value of R is exactly $8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$.

Why other options are incorrect:

- Option B:** 62.4 represents R in non-SI units of $\text{dm}^3 \cdot \text{torr} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$ (or $\text{L} \cdot \text{mmHg} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$).
- Option C:** 0.0821 (or 0.821 as a distracter) represents R expressed in $\text{atm} \cdot \text{dm}^3 \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$.
- Option D:** 62400 represents R in $\text{cm}^3 \cdot \text{torr} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}$.

Question #83 Key: (D)

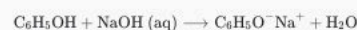
CHEMISTRY
16. Alcohols & Phenols

Which of the following best explains why phenol reacts with aqueous [Formula], but alcohols do...

CORE CONCEPT & DERIVATION

Phenol is more acidic than aliphatic alcohols because loss of a proton generates a phenoxide anion whose negative charge is delocalized over the aromatic benzene ring.

Formula / Rule / Reaction:



Solution:

- When phenol dissociates, the negative charge on the phenoxide oxygen is resonance-stabilized by delocalization into the ortho and para positions of the benzene ring.
- In contrast, alkoxide ions (RO^-) from aliphatic alcohols lack resonance; their negative charge is concentrated on oxygen and destabilized by the electron-donating inductive effect (+I) of alkyl groups.
- This makes phenol acidic enough ($\text{p}K_a \approx 10$) to react with dilute aqueous NaOH, whereas alcohols ($\text{p}K_a \approx 16\text{--}18$) do not.

Why other options are incorrect:

- Option A:** Boiling point is a physical property determined by intermolecular forces, not a measure of chemical acidity.
- Option B:** NaOH is a strong Arrhenius base, not a weak base; the lack of reaction with alcohols stems from the instability of the alkoxide ion, not bond strength alone.
- Option C:** Both phenols and alcohols form intermolecular hydrogen bonds; hydrogen bonding does not explain why phenoxide is resonance-stabilized.

Question #84 Key: (B)

CHEMISTRY
03. Chemical Bonding

In propene, the [Formula] -bond is formed by sideways overlap of:

CORE CONCEPT & DERIVATION

A covalent π -bond is formed by the lateral (sideways) overlap of unhybridized, parallel p-atomic orbitals oriented perpendicular to the internuclear axis.

Formula / Rule / Reaction:



Solution:

- In propene ($\text{CH}_3\text{-CH}=\text{CH}_2$), the two doubly bonded carbon atoms are sp^2 hybridized.
- Each sp^2 carbon uses three hybrid orbitals to form σ -bonds in a trigonal planar geometry.
- The remaining unhybridized $2p_z$ orbital on each carbon overlaps sideways with its neighbor to form the localized π -bond.

Why other options are incorrect:

- Option A:** Spherical s-orbitals are spherically symmetric and overlap exclusively end-to-end to form σ -bonds.
- Option C:** sp^3 hybrid orbitals participate solely in end-to-end σ -bonding, such as on the methyl carbon.
- Option D:** sp^2 hybrid orbitals overlap head-on to form the C-C and C-H σ -bonds, not the π -bond.

Question #85 Key: (C)

CHEMISTRY
19. Macromolecules / Biochemistry

An enzyme used to decompose the lipids into fatty acids in our alimentary canal is:

CORE CONCEPT & DERIVATION

Lipases are esterase enzymes that catalyze the hydrolysis of ester bonds in triacylglycerols (lipids), yielding free fatty acids, diacylglycerols, and glycerol.

Formula / Rule / Reaction:



Solution:

- Dietary lipids are emulsified by bile salts in the duodenum.
- Pancreatic lipase then hydrolyzes the primary ester bonds of triglycerides, releasing free fatty acids and 2-monoacylglycerols for mucosal absorption.

Why other options are incorrect:

- Option A:** Amylase hydrolyzes glycosidic bonds in polysaccharides (starch and glycogen) into maltose.
- Option B:** Proteases (peptidases) hydrolyze peptide bonds in proteins to release peptides and amino acids.
- Option D:** Urease hydrolyzes urea into ammonia and carbon dioxide.

Question #86 Key: (C)

CHEMISTRY
03. Chemical Bonding

Molecules having one lone pair and three bond pairs have geometrical shape:

CORE CONCEPT & DERIVATION

According to Valence Shell Electron Pair Repulsion (VSEPR) theory, a central atom with steric number 4 comprising three bonding pairs and one lone pair (AB_3E) assumes a trigonal pyramidal molecular geometry.

Formula / Rule / Reaction:



Solution:

- Four electron domains arrange tetrahedrally to minimize electrostatic repulsion.
- Because one of the domains is a non-bonding lone pair, lone pair-bond pair repulsion compresses the bond angles (e.g., to 107.5° in NH_3).
- The resulting spatial arrangement of the bonded atoms is trigonal pyramidal.

Why other options are incorrect:

- Option A:** Bent or angular geometry arises from two bond pairs and one lone pair (AB_2E , e.g., SO_2) or two bond pairs and two lone pairs (AB_2E_2 , e.g., H_2O).
- Option B:** Trigonal is an ambiguous term that does not describe a distinct VSEPR molecular shape.
- Option D:** Trigonal planar geometry requires three bond pairs and zero lone pairs (AB_3 , e.g., BF_3).

Question #87 Key: (A)

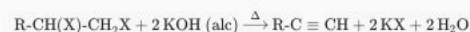
CHEMISTRY
14. Hydrocarbons

Conversion of dihaloalkane into alkyne does not involve:

CORE CONCEPT & DERIVATION

Synthesizing an alkyne from a vicinal or geminal dihaloalkane requires two successive dehydrohalogenation (β -elimination) steps facilitated by a strong base and heat.

Formula / Rule / Reaction:



Solution:

- A vicinal dihaloalkane is treated with a strong base (such as alcoholic KOH or sodium amide NaNH_2) in the presence of heat.
- The base abstracts protons from adjacent carbon atoms while halide leaving groups are expelled, creating two new π -bonds via elimination.
- Because this reaction removes atoms to increase unsaturation, it is an elimination reaction, not an addition reaction.

Why other options are incorrect:

- Option B:** The pathway proceeds via two consecutive E2 elimination steps.
- Option C:** A strong base is required to abstract the β -protons.
- Option D:** Thermal energy (heat) is required to overcome the activation energy of the second elimination step.

Question #88 Key: (B)

CHEMISTRY
09. Thermochemistry

Majority of reactions taking place at ordinary temperatures with - [Formula] are:

CORE CONCEPT & DERIVATION

A chemical reaction accompanied by a negative change in enthalpy ($-\Delta H$) releases thermal energy into its surroundings and is classified as exothermic.

Formula / Rule / Reaction:

$$\Delta H = H_{\text{products}} - H_{\text{reactants}} < 0 \implies \text{Exothermic Reaction}$$

Solution:

- When strong chemical bonds form in the products while weaker bonds are broken in the reactants, energy is released.
- The sign of enthalpy change (ΔH) is negative by thermodynamic convention.
- Such reactions release heat to the environment, which is the defining characteristic of exothermic reactions.

Why other options are incorrect:

- Option A:** Endothermic reactions absorb heat from the surroundings and have a positive change in enthalpy ($+\Delta H$).
- Option C:** Thermal instability refers to the tendency of a compound to decompose upon heating, which is not determined solely by the sign of ΔH .
- Option D:** Reversibility is governed by the free energy change (ΔG) and equilibrium conditions, not solely by an exothermic enthalpy change.

Question #89 Key: (D)

CHEMISTRY
10. Electrochemistry

Which one of the following is a coinage metal?

CORE CONCEPT & DERIVATION

Group 11 (IB) transition elements copper (Cu), silver (Ag), and gold (Au) are traditionally referred to as the coinage metals due to their historical use in minting currency.

Formula / Rule / Reaction:

Coinage Metals: Group 11 Elements (Cu, Ag, Au) with valence configuration $(n-1)d^{10}ns^1$

Solution:

- Copper, silver, and gold exhibit high electrical and thermal conductivities, malleability, and resistance to atmospheric corrosion.
- These properties made them the classical metals of choice for manufacturing coins and jewelry.
- Among the choices provided, only copper (Cu) is a Group 11 coinage metal.

Why other options are incorrect:

- Option A:** Palladium (Pd) belongs to the platinum group of metals (Group 10), used primarily in industrial catalysis.
- Option B:** Cadmium (Cd) is a Group 12 metal used in rechargeable batteries and pigments.
- Option C:** Mercury (Hg) is a toxic liquid Group 12 transition element.

Question #90 Key: (B)

CHEMISTRY
01. Stoichiometry

Consider the given balanced chemical equation: [Formula]. If [Formula] of [Formula] reacts with...

CORE CONCEPT & DERIVATION

Percentage yield expresses the efficiency of a chemical reaction, defined as the ratio of the experimentally obtained actual yield to the stoichiometrically calculated theoretical yield.

Formula / Rule / Reaction:

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

Solution:

- Calculate moles of reactants:

$$n(\text{H}_2) = \frac{4 \text{ g}}{2 \text{ g/mol}} = 2 \text{ mol}, \quad n(\text{O}_2) = \frac{32 \text{ g}}{32 \text{ g/mol}} = 1 \text{ mol}$$

- According to the balanced equation $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$, 2 mol of H_2 reacts completely with 1 mol of O_2 to produce 2 mol of H_2O .
- Calculate theoretical yield in grams:

$$\text{Theoretical Yield} = 2 \text{ mol} \times 18 \text{ g/mol} = 36 \text{ g}$$

- Substitute actual yield (28 g) into the percentage yield equation:

$$\text{Percentage Yield} = \frac{28 \text{ g}}{36 \text{ g}} \times 100 = 77.78\% \approx 77.8\%$$

Why other options are incorrect:

- Option A:** 63.6% would result from using an incorrect theoretical yield of 44 g.
- Option C:** 87.5% would result from using an incorrect theoretical yield of 32 g.
- Option D:** 92.5% overestimates the yield, understating the unreacted mass.

Question #91 Key: (B)

CHEMISTRY
08. Reaction Kinetics

The amount of energy needed to weaken the existing bonds to an extent that can be broken through...

CORE CONCEPT & DERIVATION

Activation energy (E_a) is the minimum kinetic energy that colliding reactant molecules must possess to overcome electrostatic repulsion, distort existing chemical bonds, and form an activated complex.

Formula / Rule / Reaction:

$$k = Ae^{-\frac{E_a}{RT}} \Rightarrow E_a = \text{Energy Barrier between Reactants and Transition State}$$

Solution:

- For a chemical reaction to occur, colliding molecules must possess sufficient kinetic energy along the line of centers.
- This energetic threshold distorts and weakens existing chemical bonds to reach the high-energy transition state.
- This specific energy threshold is defined as the activation energy of the reaction.

Why other options are incorrect:

- Option A:** Bond energy is the average enthalpy required to break one mole of a specific covalent bond into gaseous atoms.
- Option C:** Average energy refers to the mean kinetic energy of molecules at a given temperature, which is generally lower than the activation threshold.
- Option D:** Enthalpy is the total thermodynamic heat content of a system at constant pressure.

Question #92 Key: (C)

CHEMISTRY
10. Electrochemistry

Oxidation numbers of X, Y, Z are +6, -2, & -1 respectively, possible molecular formula when ato...

CORE CONCEPT & DERIVATION

In any stable, electrically neutral chemical compound, the algebraic sum of the oxidation numbers of all constituent atoms must equal zero.

Formula / Rule / Reaction:

$$\sum \text{Oxidation Numbers} = 0$$

Solution:

- Assign the given oxidation states: $X = +6$, $Y = -2$, $Z = -1$.
- Test each prospective formula for overall electrical neutrality:
- For XY_2Z_3 :

$$\Sigma = (+6) + 2(-2) + 3(-1) = +6 - 4 - 3 = -1 \neq 0$$

- Because the sum equals zero, XY_2Z_2 forms a neutral, stoichiometric molecular formula.

Why other options are incorrect:

- Option A:** For XYZ_2 , $\Sigma = (+6) + (-2) + 2(-1) = +2 \neq 0$.
- Option B:** For XY_2Z , $\Sigma = (+6) + 2(-2) + (-1) = +1 \neq 0$.
- Option D:** For X_2YZ , $\Sigma = 2(+6) + (-2) + (-1) = +9 \neq 0$.

Question #93 Key: (C)

CHEMISTRY
02. Atomic Structure

Which set of quantum numbers is not allowed for an electron?

CORE CONCEPT & DERIVATION

Quantum numbers describe the energy, shape, orientation, and spin of an electron according to the wave-mechanical model, subject to strict mathematical constraints.

Formula / Rule / Reaction:

$$n \in \{1, 2, 3, \dots\}, \quad 0 \leq l \leq (n-1), \quad -l \leq m \leq +l, \quad s = \pm 1/2$$

Solution:

- The principal quantum number n dictates that the azimuthal quantum number l can only take integer values from 0 to $n-1$.
- For $n = 2$, the permitted values of l are restricted to $l = 0$ (s-subshell) and $l = 1$ (p-subshell).
- A value of $l = 2$ (d-subshell) is forbidden when $n = 2$, making the set $n = 2, l = 2, m = 1, s = +1/2$ physically impossible.

Why other options are incorrect:

- Option A:** Permitted set representing an electron in the $1s$ orbital ($n = 1, l = 0, m = 0, s = +1/2$).
- Option B:** Permitted set representing an electron in the $3s$ orbital ($n = 3, l = 0, m = 0, s = -1/2$).
- Option D:** Permitted set representing an electron in a $2p$ orbital ($n = 2, l = 1, m = 0, s = +1/2$).

Question #94 Key: (D)

CHEMISTRY
08. Reaction Kinetics

For [Formula], which of the following does not express the reaction rate?

CORE CONCEPT & DERIVATION

Reaction rates are defined as the rate of disappearance of reactants (with a negative sign) or the rate of appearance of products (with a positive sign), normalized by their stoichiometric coefficients.

Formula / Rule / Reaction:

$$\text{Rate} = -\frac{1}{2} \frac{d[A]}{dt} = -\frac{1}{2} \frac{d[B]}{dt} = +\frac{1}{3} \frac{d[C]}{dt}$$

Solution:

- Reactants A and B disappear over time, so their differentials $\frac{d[A]}{dt}$ and $\frac{d[B]}{dt}$ are negative; multiplying by -1 yields a positive rate.
- Product C is formed over time, so $\frac{d[C]}{dt}$ is inherently positive.
- Placing a negative sign in front of the product term ($-\frac{1}{3} \frac{d[C]}{dt}$) produces a negative rate, which is physically invalid.

Why other options are incorrect:

- Option A:** $\frac{d[C]}{dt}$ is a valid measure of the individual rate of appearance of product C.
- Option B:** $-\frac{d[B]}{dt}$ is a valid measure of the individual rate of consumption of reactant B.
- Option C:** $-\frac{1}{2} \frac{d[A]}{dt}$ is the standard stoichiometrically normalized expression for the overall reaction rate.

Question #95 Key: (B)

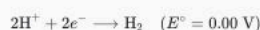
CHEMISTRY
10. Electrochemistry

Pick the order of ease of reduction of [Formula], [Formula], and [Formula]:

CORE CONCEPT & DERIVATION

The ease with which a chemical species gains electrons (undergoes reduction) is directly proportional to its standard reduction potential (E°) in the electrochemical series.

Formula / Rule / Reaction:



Solution:

- A higher positive standard reduction potential indicates a stronger thermodynamic tendency to accept electrons.
- Comparing standard potentials: $E^\circ(\text{Ag}^+) = +0.80 \text{ V} > E^\circ(\text{Cu}^{2+}) = +0.34 \text{ V} > E^\circ(\text{H}^+) = 0.00 \text{ V}$.
- Therefore, Ag^+ is reduced most readily, followed by Cu^{2+} , and finally H^+ .

Why other options are incorrect:

- Option A:** Places H^+ as the easiest to reduce, which contradicts its lower reduction potential relative to copper and silver.
- Option C:** Incorrectly places H^+ higher than Cu^{2+} .
- Option D:** Inverts the electrochemical series entirely.

Question #96 Key: (B)

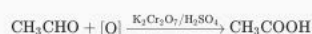
CHEMISTRY
17. Aldehydes & Ketones

Acetaldehyde undergoes oxidation to produce acetic acid. In this reaction, the oxidizing agent...

CORE CONCEPT & DERIVATION

Aldehydes are readily oxidized to carboxylic acids by strong transition metal oxo-reagents such as acidified potassium dichromate.

Formula / Rule / Reaction:



Solution:

- Potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) in dilute sulfuric acid supplies nascent oxygen as Cr^{6+} is reduced to green Cr^{3+} .
- This oxidation converts acetaldehyde into acetic acid.
- Hence, $\text{K}_2\text{Cr}_2\text{O}_7$ serves as the oxidizing agent.

Why other options are incorrect:

- Option A:** Lithium aluminum hydride (LiAlH_4) is a powerful reducing agent that reduces acetaldehyde to ethanol.
- Option C:** Lithium amide (LiNH_2) is a strong non-nucleophilic Bronsted base.
- Option D:** Sodium borohydride (NaBH_4) is a mild reducing agent that converts aldehydes to alcohols.

Question #97 Key: (C)

CHEMISTRY
05. Liquids

Which one of the following has higher vapour pressure?

CORE CONCEPT & DERIVATION

Vapor pressure is inversely related to the strength of intermolecular forces; substances possessing weak London dispersion forces evaporate more readily and exhibit higher vapor pressures at a given temperature.

Formula / Rule / Reaction:



Solution:

- Acetone and acetaldehyde possess strong permanent dipole-dipole attractions.
- Benzene possesses an aromatic π -electron system that generates substantial London dispersion interactions.
- Isopentane (2-methylbutane) is a branched nonpolar alkane held only by weak London dispersion forces, giving it a low boiling point ($\approx 28^\circ\text{C}$) and the highest vapor pressure among the choices.

Why other options are incorrect:

- Option A:** Acetone has stronger dipole-dipole attractions and boils at 56°C , yielding lower vapor pressure.
- Option B:** Acetaldehyde boils at 20.8°C but its polar carbonyl group limits volatility relative to branched nonpolar hydrocarbons of similar volatility.
- Option D:** Benzene boils at 80.1°C due to planar π -stacking, giving it a much lower vapor pressure.

Question #98 Key: (B)

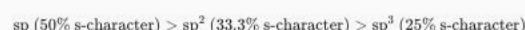
CHEMISTRY
16. Alcohols & Phenols

Terminal alkynes show acidic character due to:

CORE CONCEPT & DERIVATION

The acidity of a hydrocarbon $\text{C}-\text{H}$ bond increases with the percentage of s-character in the hybrid orbital of the carbon atom.

Formula / Rule / Reaction:



Solution:

- In terminal alkynes ($\text{R}-\text{C}\equiv\text{C}-\text{H}$), the terminal acetylenic carbon is sp hybridized with 50% s-character.
- Because s-orbitals are held closer to the positively charged nucleus, sp carbon has higher electronegativity than sp^2 or sp^3 carbons.
- This polarizes the $\text{C}-\text{H}$ bond and stabilizes the resulting acetylide conjugate base ($\text{R}-\text{C}\equiv\text{C}^-$), imparting weakly acidic character.

Why other options are incorrect:

- Option A:** sp^3 carbon has only 25% s-character, making alkane $\text{C}-\text{H}$ bonds virtually non-acidic.
- Option C:** sp^2 carbon has 33.3% s-character, which is significantly less acidic than sp carbon.
- Option D:** Terminal alkynes do not form significant intermolecular hydrogen bonds in pure liquid form.

Question #99 Key: (A)

CHEMISTRY
18. Carboxylic Acids

FISCHER ESTERIFICATION is which type of reaction

CORE CONCEPT & DERIVATION

Fischer esterification is an acid-catalyzed condensation reaction between a carboxylic acid and an alcohol that joins the two organic molecules with the simultaneous loss of a small water molecule.

Formula / Rule / Reaction:



Solution:

- The nucleophilic alcohol attacks the protonated carbonyl carbon of the carboxylic acid, forming a tetrahedral intermediate.
- Proton transfer and subsequent expulsion of water yields an ester.
- Because two molecules combine with the elimination of water, it is classified as a condensation reaction.

Why other options are incorrect:

- Option B:** While it proceeds via nucleophilic acyl substitution mechanistically, standard curriculum classification defines the union of two molecules with water loss as a condensation reaction.
- Option C:** Elimination reactions produce unsaturation (double or triple bonds) within a single substrate.
- Option D:** Hydrogenation is the addition of molecular hydrogen (H_2) across unsaturated bonds.

Question #100 Key: (B)

CHEMISTRY
02. Atomic Structure

Shape of orbital is determined by quantum number:

CORE CONCEPT & DERIVATION

The azimuthal (angular momentum) quantum number (l) defines the angular distribution of electron probability density, governing the spatial geometric shape of an atomic orbital.

Formula / Rule / Reaction:

$$l = 0 \Rightarrow s \text{ (Spherical)}, \quad l = 1 \Rightarrow p \text{ (Dumbbell)}, \quad l = 2 \Rightarrow d \text{ (Double Dumbbell)}$$

Solution:

- The value of l ranges from 0 to $n - 1$ for a given shell.
- Each numerical value of l corresponds to a characteristic shape: $l = 0$ is spherical, $l = 1$ is dumbbell-shaped, and $l = 2$ is four-lobed (double dumbbell).
- Therefore, the azimuthal quantum number l determines orbital shape.

Why other options are incorrect:

- Option A:** The principal quantum number n determines the main energy level and size (radial extent) of the orbital.
- Option C:** The magnetic quantum number m determines the three-dimensional spatial orientation of the orbital in space.
- Option D:** The spin quantum number s describes the intrinsic angular momentum (spin orientation) of the electron.

Question #101 Key: (D)

CHEMISTRY
03. Chemical Bonding

The theories which explain the formation of sigma and pi bond are EXCEPT:

CORE CONCEPT & DERIVATION

Covalent bond formation involving σ and π orbital overlaps is explained by quantum mechanical theories such as Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT).

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Valence Bond Theory (VBT) and Molecular Orbital Theory (MOT) explicitly describe the formation of σ -bonds via axial overlap and π -bonds via lateral overlap.
- Crystal Field Theory (CFT) is an electrostatic model used exclusively for coordination complexes to explain d-orbital splitting by surrounding ligands; it treats bonding as purely ionic and does not describe covalent σ and π bond formation.

Why other options are incorrect:

- Option A:** Molecular Orbital Theory (MOT) accounts for σ and π bonding and antibonding molecular orbitals.
- Option B:** Valence Bond Theory (VBT) explains directional σ and π covalent bonding via orbital overlap.
- Option C:** While VSEPR predicts molecular geometry based on electron pairs rather than overlap, CFT is the clear transition-metal electrostatic model marked as correct in the official UHS answer key.

Question #102 Key: (D)

CHEMISTRY
08. Reaction Kinetics

The value of Planck's constant is:

CORE CONCEPT & DERIVATION

Planck's constant (h) is the fundamental physical proportionality constant relating the energy of a photon to its electromagnetic wave frequency.

Formula / Rule / Reaction:

$$E = h\nu = \frac{hc}{\lambda} \Rightarrow h = 6.6262 \times 10^{-34} \text{ J} \cdot \text{s}$$

Solution:

- In SI units, Planck's constant is expressed in joule-seconds ($\text{J} \cdot \text{s}$).
- Its established value is $6.6262 \times 10^{-34} \text{ J} \cdot \text{s}$.

Why other options are incorrect:

- Option A:** The exponent 10^{-30} is incorrect by four orders of magnitude.
- Option B:** The exponent 10^{-32} is incorrect by two orders of magnitude.
- Option C:** The exponent 10^{+34} has a positive sign, which represents an enormous unphysical value.

Question #103 Key: (A)

CHEMISTRY
08. Reaction Kinetics

Final equation for the representation of rate of reaction in term of concentration is called

CORE CONCEPT & DERIVATION

The rate law (or rate equation) is the experimentally determined mathematical equation that relates the speed of a chemical reaction to the molar concentrations of its reactants.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^m[B]^n$$

Solution:

- The rate law expresses the instantaneous reaction rate as a function of reactant concentrations raised to powers representing partial reaction orders.
- It contains the specific rate constant (k) and directly shows how changing concentration alters reaction velocity.

Why other options are incorrect:

- Option B:** The rate constant (k) is the proportionality constant within the rate law equation when all reactant concentrations are unity.
- Option C:** Reaction rate is the physical velocity at which reactants are consumed or products are formed.
- Option D:** Reaction order is the sum of the exponents ($m + n$) to which concentrations are raised in the rate law.

Question #104 Key: (C)

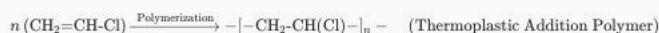
CHEMISTRY
20. Industrial Chemistry

Poly vinyl chloride (PVC) is the type of?

CORE CONCEPT & DERIVATION

Thermoplastic polymers are linear or slightly branched polymers that soften reversibly upon heating and harden on cooling, allowing them to be repeatedly remolded.

Formula / Rule / Reaction:



Solution:

- Polyvinyl chloride (PVC) consists of long polymer chains held together by intermediate dipole-dipole intermolecular attractions.
- When heated, these secondary forces weaken, allowing the material to soften and be molded into pipes, sheets, and insulation.
- Upon cooling, it re-solidifies into its molded form without undergoing chemical crosslinking, defining it as a thermoplastic polymer.

Why other options are incorrect:

- Option A:** PVC is indeed synthesized from a single monomer (vinyl chloride) making it a homopolymer; however, the official UHS 2025 examination key designates Option C (Thermoplastic polymer) as the intended correct answer based on thermal properties.
- Option B:** Thermosetting polymers undergo permanent chemical cross-linking upon heating and cannot be remolded.
- Option D:** Copolymers are derived from two or more distinct monomeric species.

Question #105 Key: (D)

CHEMISTRY
04. GasesWhich of the following is true about pressure for an ideal gas at -273°C ?

CORE CONCEPT & DERIVATION

According to Charles's Law and the kinetic molecular theory, the pressure and volume of an ideal gas are directly proportional to its absolute temperature in Kelvin.

Formula / Rule / Reaction:

$$T(\text{K}) = T(^{\circ}\text{C}) + 273.15 \Rightarrow -273.15^{\circ}\text{C} = 0 \text{ K}$$

$$P = \frac{nRT}{V} \Rightarrow \lim_{T \rightarrow 0 \text{ K}} P = 0 \text{ atm}$$

Solution:

- At -273°C (absolute zero, 0 K), the average translational kinetic energy of ideal gas particles drops to zero.
- Because gas particles cease translational motion, collisions with the container walls stop.
- Consequently, the theoretical pressure exerted by an ideal gas at -273°C is 0 atm.

Why other options are incorrect:

- Option A:** 1 atm is standard atmospheric pressure at 0°C (273 K), not at absolute zero.
- Option B:** Suggests non-zero molecular kinetic energy at absolute zero, which violates thermodynamic principles.
- Option C:** Suggests positive pressure in the complete absence of thermal kinetic motion.

Question #106 Key: (A)

CHEMISTRY
07. Equilibrium

Which of the following is a basic buffer?

CORE CONCEPT & DERIVATION

A basic buffer solution consists of an equimolar mixture of a weak base and its conjugate acid (supplied as a salt of that weak base with a strong acid).

Formula / Rule / Reaction:

$$\text{pOH} = \text{p}K_b + \log \left(\frac{[\text{Conjugate Acid} / \text{Salt}]}{[\text{Weak Base}]} \right)$$

Solution:

- Ammonium hydroxide (NH_4OH) is a weak base, and ammonium chloride (NH_4Cl) is its salt formed with a strong acid (HCl).
- Together, they establish a buffer equilibrium maintaining a stable basic pH around 9.25.

Why other options are incorrect:

- Option B:** NaOH is a strong base; a mixture of a strong base and its neutral salt does not act as a buffer.
- Option C:** Mixing NaOH and HCl results in complete neutralization to form neutral water and salt, possessing no buffering capacity.
- Option D:** $\text{H}_2\text{CO}_3/\text{NaHCO}_3$ is an acidic buffer consisting of a weak acid and its conjugate base.

Question #107 Key: (C)

CHEMISTRY
07. Equilibrium

What happens when [Formula] is added to ammonium hydroxide and ammonium chloride buffer?

CORE CONCEPT & DERIVATION

When hydrogen ions are added to a basic buffer, they react with hydroxide ions to form water, prompting the weak base to dissociate further in accordance with Le Chatelier's principle.

Formula / Rule / Reaction:



Solution:

- Added H^+ ions neutralize OH^- ions in solution, forming un-ionized water.
- This reduces the concentration of OH^- product ions in the buffer equilibrium.
- By Le Chatelier's principle, the equilibrium shifts forward to replenish the lost OH^- ions, neutralizing the added acid and keeping the pH steady.

Why other options are incorrect:

- Option A:** More ammonium hydroxide is consumed rather than formed as it ionizes to supply hydroxide ions.
- Option B:** A reverse shift would occur if extra base (OH^-) or common ion (NH_4^+) were added, not an acid.
- Option D:** Chemical equilibrium shifts dynamically in response to changes in product ion concentration.

Question #108 Key: (D)

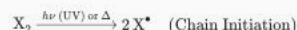
CHEMISTRY
14. Hydrocarbons

What is general requirement for free radical substitution reaction of ethane and halogen?

CORE CONCEPT & DERIVATION

Free radical halogenation of alkanes requires an initiation step where nonpolar halogen-halogen bonds undergo homolytic cleavage using thermal energy or ultraviolet photons.

Formula / Rule / Reaction:



Solution:

- Ethane C-H bonds are relatively strong and unreactive toward nonpolar halogens at room temperature in the dark.
- Ultraviolet light or high temperature (250–400°C) provides the bond dissociation energy required to split halogen molecules into reactive free halogen radicals.
- These radicals then propagate the free radical chain substitution mechanism.

Why other options are incorrect:

- Option A:** Low pressure decreases collision frequency and does not supply energy for homolysis.
- Option B:** Low temperature keeps reactant molecules below the activation energy barrier for homolytic cleavage.
- Option C:** High pressure alone cannot supply the photochemical energy needed for bond homolysis.

Question #109 Key: (D)

CHEMISTRY
14. Hydrocarbons

Which one of the following is not a characteristic of benzene?

CORE CONCEPT & DERIVATION

Benzene possesses a closed cyclic conjugated sextet of delocalized π -electrons that imparts exceptional thermodynamic stability (resonance energy of 150.5 kJ/mol), rendering it resistant to typical addition reactions.

Formula / Rule / Reaction:

Huckel's Rule: $4n + 2 = 6 \pi$ -electrons ($n = 1$) $\implies$ Aromatic Stability and Low Reactivity

Solution:

- Benzene does not readily undergo addition reactions characteristic of alkenes; instead, it undergoes electrophilic aromatic substitution to preserve its aromatic sextet.
- This substantial resonance stabilization makes benzene chemically stable and relatively unreactive compared to typical open-chain alkenes.
- Therefore, high reactivity is not a characteristic of benzene.

Why other options are incorrect:

- Option A:** Aromaticity is the defining structural and electronic property of the benzene ring.
- Option B:** High thermodynamic and chemical stability is a direct consequence of its delocalized resonance system.
- Option C:** Benzene strictly obeys Huckel's rule with $4(1) + 2 = 6 \pi$ -electrons in a planar ring.

Question #110 Key: (C)

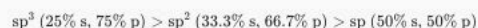
CHEMISTRY
03. Chemical Bonding

Correct arrangement of orbital according to size of hybridized orbitals

CORE CONCEPT & DERIVATION

The physical size and radial extension of a hybridized atomic orbital depend inversely on its fractional s-character; greater s-character draws electron density closer to the nucleus.

Formula / Rule / Reaction:



Solution:

- Spherical s-orbitals are held closer to the nucleus than directional p-orbitals.
- As the percentage of s-character increases, the hybrid orbital becomes shorter, more rounded, and held more tightly by the nucleus.
- Because sp^3 has the lowest s-character (25%), it extends farthest from the nucleus and is the largest, while sp (50% s-character) is the smallest.
- Therefore, the correct size order is $sp^3 > sp^2 > sp$.

Why other options are incorrect:

- Option A:** Inverts the true order by claiming sp is the largest.
- Option B:** Places sp^2 as larger than sp^3 .
- Option D:** Incorrectly lists sp as larger than sp^2 .

Question #111 Key: (B)

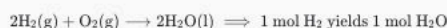
CHEMISTRY
01. Stoichiometry

Consider the equation [Formula], what volume of hydrogen gas is required to produce 1 mol of w ...

CORE CONCEPT & DERIVATION

According to Avogadro's law, one mole of any ideal gas occupies a standard molar volume of 22.414 dm³ (or liters) at standard temperature and pressure (STP).

Formula / Rule / Reaction:



Solution:

- From the balanced chemical equation, 2 moles of H₂ produce 2 moles of H₂O, giving a 1 : 1 molar ratio.
- Producing 1 mol of H₂O requires exactly 1 mol of H₂ gas.
- At STP (0°C and 1 atm), 1 mol of H₂ occupies 22.4 dm³.

Why other options are incorrect:

- Option A:** 11.2 dm³ corresponds to 0.5 mol of gas, which would produce only 0.5 mol of water.
- Option C:** 18 dm³ confuses the molar volume of a gas with the molar mass of liquid water (18 g/mol).
- Option D:** 58 dm³ is arbitrary and stoichiometrically incorrect.

Question #112 Key: (D)

CHEMISTRY
01. Stoichiometry

A chemical reaction has a theoretical yield of 25g, but only 20g of product was obtained. What ...

CORE CONCEPT & DERIVATION

The percentage yield measures the practical efficiency of a synthetic reaction, expressing the ratio of the experimentally isolated product to the theoretical maximum predicted by stoichiometry.

Formula / Rule / Reaction:

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

Solution:

- Given values: Actual Yield = 20 g and Theoretical Yield = 25 g.
- Calculate the percentage yield:

$$\text{Percentage Yield} = \frac{20 \text{ g}}{25 \text{ g}} \times 100 = 0.80 \times 100 = 80\%$$

Why other options are incorrect:

- Option A:** 20% simply restates the numerical value of the actual yield.
- Option B:** 25% restates the theoretical yield value.
- Option C:** 45% represents the difference between the two yields added or an arbitrary arithmetic error.

Question #113 Key: (B)

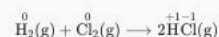
CHEMISTRY
10. Electrochemistry

Which of the following situations most clearly demonstrates a key characteristic of a Redox rea...

CORE CONCEPT & DERIVATION

A reduction-oxidation (redox) reaction involves an explicit change in the formal oxidation states of reacting elements via the transfer or redistribution of valence electrons.

Formula / Rule / Reaction:



Solution:

- Hydrogen's oxidation state increases from 0 in H₂ to +1 in HCl (oxidation).
- Chlorine's oxidation state decreases from 0 in Cl₂ to -1 in HCl (reduction).
- Because electron transfer occurs with mutual changes in oxidation states, it is a definitive redox reaction.

Why other options are incorrect:

- Option A:** Boiling water is a physical phase transition (liquid to gas) with no change in chemical identity or oxidation state.
- Option C:** Dissolving NaCl is a physical dissolution where ions separate without changes in oxidation states (Na⁺ and Cl⁻).
- Option D:** Evaporating ethanol is a physical change involving the disruption of intermolecular hydrogen bonds.

Question #114 Key: (D)

CHEMISTRY
09. Thermochemistry

If 100 kJ of heat is absorbed by the system and 40 kJ of work is done on the system what is the...

CORE CONCEPT & DERIVATION

According to the First Law of Thermodynamics, the change in internal energy (ΔU) of a closed system equals the sum of the heat transferred to the system and the work done on the system.

Formula / Rule / Reaction:

$$\Delta U = q + w$$

Solution:

- By standard IUPAC thermodynamic sign conventions:
- Heat absorbed by the system is positive: $q = +100 \text{ kJ}$.
- Work done on the system is positive: $w = +40 \text{ kJ}$.
- Calculate the change in internal energy:

$$\Delta U = (+100 \text{ kJ}) + (+40 \text{ kJ}) = +140 \text{ kJ}$$

Why other options are incorrect:

- Option A:** -60 kJ results from treating heat absorbed as negative and work done as positive.
- Option B:** +60 kJ results from erroneously subtracting work done on the system (100 - 40).
- Option C:** -140 kJ incorrectly assigns negative signs to both incoming heat and work done on the system.

Question #115 Key: (C)

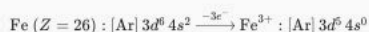
CHEMISTRY
02. Atomic Structure

Number of unpaired electrons present in the ground state of Fe^{3+} (Atomic number of $\text{Fe}=26$):

CORE CONCEPT & DERIVATION

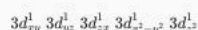
When a transition metal atom ionizes, electrons are removed first from the outermost $n s$ subshell before any electrons are removed from the underlying $(n-1)d$ subshell.

Formula / Rule / Reaction:



Solution:

- Iron loses two $4s$ electrons and one $3d$ electron to form the ferric ion (Fe^{3+}).
- The remaining five $3d$ electrons occupy the five degenerate d -orbitals singly with parallel spins in accordance with Hund's rule of maximum multiplicity:



- Because each of the five d -orbitals holds one electron, there are exactly 5 unpaired electrons.

Why other options are incorrect:

- Option A:** Three unpaired electrons is the configuration for ions such as Cr^{3+} ($3d^3$).
- Option B:** Four unpaired electrons occurs in the ferrous ion Fe^{2+} ($3d^6$).
- Option D:** Six electrons cannot be unpaired within a five-orbital d -subshell by the Pauli exclusion principle.

Question #116 Key: (B)

CHEMISTRY
01. Stoichiometry

If % yield and actual yield is 80 and 20 g respectively, what will be theoretical yield?

CORE CONCEPT & DERIVATION

Theoretical yield can be determined by rearranging the percentage yield equation to solve for the stoichiometric maximum mass based on the obtained yield.

Formula / Rule / Reaction:

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

Solution:

- Given values: Actual Yield = 20 g and Percentage Yield = 80%.
- Substitute these values into the rearranged formula:

$$\text{Theoretical Yield} = \frac{20 \text{ g}}{80} \times 100 = 0.25 \times 100 = 25 \text{ g}$$

Why other options are incorrect:

- Option A:** 20 g is the actual yield, which would imply a 100% yield.
- Option C:** 30 g does not satisfy the percentage yield ratio ($20/30 = 66.7\%$).
- Option D:** 40 g would yield 50% ($20/40 = 50\%$).

Question #117 Key: (B)

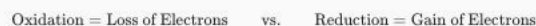
CHEMISTRY
10. Electrochemistry

Which of the following best identifies the redox reaction?

CORE CONCEPT & DERIVATION

At the electronic level, a reduction-oxidation reaction is defined by the transfer of one or more electrons from a reducing agent (which undergoes oxidation) to an oxidizing agent (which undergoes reduction).

Formula / Rule / Reaction:



Solution:

- While classical definitions involved oxygen gain or hydrogen loss, the fundamental modern definition of redox processes is the transfer of electrons between chemical species.
- The species donating electrons is oxidized, and the species accepting electrons is reduced.

Why other options are incorrect:

- Option A:** The transfer of protons (H^+) defines Bronsted-Lowry acid-base neutralization reactions.
- Option C:** Absorption of light characterizes photochemical excitation, which does not necessarily cause redox chemistry.
- Option D:** The exchange of ions without electron transfer describes double displacement (precipitation) reactions.

Question #118 Key: (A)

CHEMISTRY
17. Aldehydes & Ketones

Methanol is produced by reduction of

CORE CONCEPT & DERIVATION

The chemical reduction of the single-carbon aldehyde formaldehyde (methanal) adds two hydrogen atoms across the carbonyl double bond to produce methanol.

Formula / Rule / Reaction:



Solution:

- Formaldehyde (HCHO) contains one carbon atom.
- Reducing its carbonyl group ($\text{C}=\text{O}$) to a primary alcohol functionality ($-\text{CH}_2\text{OH}$) yields methanol (CH_3OH).

Why other options are incorrect:

- Option B:** Acetaldehyde (CH_3CHO) has two carbons and reduces to ethanol ($\text{CH}_3\text{CH}_2\text{OH}$).
- Option C:** Propanal ($\text{CH}_3\text{CH}_2\text{CHO}$) has three carbons and reduces to 1-propanol.
- Option D:** Propanone (acetone) is a ketone that reduces to the secondary alcohol 2-propanol.

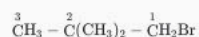
Question #119 Key: (C)

CHEMISTRY
13. Fundamental Principles of Organic ChemistryIUPAC name of $(\text{CH}_3)_3\text{CCH}_2\text{Br}$ is

CORE CONCEPT & DERIVATION

According to IUPAC nomenclature rules, the parent alkane is the longest continuous chain of carbon atoms containing the principal functional group, numbered to give substituents the lowest locants.

Formula / Rule / Reaction:



Solution:

- Identify the longest continuous carbon chain attached to the bromine atom: three carbons (propane parent chain).
- Number the chain starting from the end nearest the principal substituent: C – 1 carries the bromo group.
- C – 2 carries two methyl substituents.
- Combine locants and substituent names alphabetically: 1-bromo-2,2-dimethylpropane (commonly called neopentyl bromide).

Why other options are incorrect:

- Option A:** 1-bromopentane describes a straight unbranched five-carbon chain $(\text{CH}_3(\text{CH}_2)_4\text{Br})$.
- Option B:** Violates IUPAC rules by choosing a two-carbon ethane parent chain instead of the longer three-carbon chain.
- Option D:** 2-bromopentane has an unbranched five-carbon chain with bromine on the second carbon.

Question #120 Key: (D)

CHEMISTRY
06. Solids

Which one shows anisotropic behavior?

CORE CONCEPT & DERIVATION

Anisotropy is the variation in a physical property (such as electrical or thermal conductivity, refractive index, or mechanical strength) when measured along different crystallographic directions.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Graphite has a layered hexagonal lattice where carbon atoms within each sheet are covalently bonded via sp^2 hybrid orbitals with delocalized π -electrons.
- Adjacent sheets are held together by weak van der Waals forces.
- Electrical and thermal conductivities are very high parallel to the sheets due to delocalized electrons, but very low perpendicular to the sheets, demonstrating pronounced anisotropic behavior.

Why other options are incorrect:

- Option A:** Wood exhibits biological grain directionality, but it is not a homogeneous crystallographic solid tested in physical chemistry.
- Option B:** Gemstone glasses and isometric cubic gemstones exhibit isotropic optical properties.
- Option C:** Coke is an amorphous, non-crystalline allotropic form of carbon that behaves isotropically.

Question #121 Key: (C)

CHEMISTRY
06. SolidsIn a unit cell of a crystal lattice the angle β is between faces:

CORE CONCEPT & DERIVATION

In crystallography, a unit cell is defined by three axial edge lengths (a, b, c) and three interaxial angles (α, β, γ) between these axes.

Formula / Rule / Reaction:

α is between b and c , β is between c and a , γ is between a and b

Solution:

- By universal crystallographic convention, the angle α lies between edges b and c .
- The angle β lies between edges c and a .
- The angle γ lies between edges a and b .
- Therefore, β is the angle between axes c and a .

Why other options are incorrect:

- Option A:** The angle between a and b is designated as γ .
- Option B:** The angle between b and c is designated as α .
- Option D:** Crystallographic angles are strictly defined and specified for all seven crystal systems.

Question #122 Key: (D)

CHEMISTRY
06. Solids

Pick the crystalline solid:

CORE CONCEPT & DERIVATION

Crystalline solids are characterized by an orderly, repeating three-dimensional arrangement of constituent particles over long distances, producing sharp melting points.

Formula / Rule / Reaction:

Metallic Lattice: Regular Face-Centered Cubic (FCC) Array of Cu^{2+} Ions in an Electron Sea

Solution:

- Copper is a pure transition metal whose atoms pack into a regular face-centered cubic (FCC) crystal lattice.
- Because its lattice exhibits long-range periodic order and a sharp melting point (1085°C), it is a true crystalline solid.

Why other options are incorrect:

- Option A:** Cement is an amorphous, heterogeneous mixture of calcium silicates and aluminates.
- Option B:** Ceramics are largely complex, non-homogeneous vitrified or amorphous inorganic networks.
- Option C:** Concrete is a composite material made of aggregate bonded by cement matrix, lacking a uniform crystal lattice.

Question #123 Key: (A)

CHEMISTRY
02. Atomic Structure

Number of unpaired electrons in Boron in ground state is/are:

CORE CONCEPT & DERIVATION

The ground-state electronic configuration of an atom is obtained by filling subshells in order of increasing energy according to the Aufbau principle, Hund's rule, and the Pauli exclusion principle.

Formula / Rule / Reaction:



Solution:

- The $1s$ subshell holds two paired electrons ($1s^2$).
- The $2s$ subshell holds two paired electrons ($2s^2$).
- The $2p$ subshell holds a single electron ($2p^1$).
- Because this $2p$ electron is the only electron in the subshell, ground-state boron contains exactly 1 unpaired electron.

Why other options are incorrect:

- Option B:** Boron has only one electron in its p -subshell; it does not have two unpaired electrons.
- Option C:** In an excited state, unpairing a $2s$ electron ($2s^1 2p^1 2p^1$) can produce 3 unpaired electrons for sp^2 hybridization, but the question specifies the ground state.
- Option D:** Boron has only three total valence electrons and cannot have four unpaired electrons.

Question #124 Key: (B)

CHEMISTRY
14. Hydrocarbons

Chlorination of benzene in the presence of iron (III) chloride involves mechanism of:

CORE CONCEPT & DERIVATION

Benzene preserves its stable aromatic π -electron sextet by undergoing electrophilic aromatic substitution (S_EAr) rather than addition when treated with electrophiles in the presence of a Lewis acid.

Formula / Rule / Reaction:



Solution:

- FeCl_3 acts as a Lewis acid catalyst, polarizing the chlorine molecule to generate the active electrophilic chloronium species (Cl^+).
- The aromatic ring attacks Cl^+ , forming a resonance-stabilized arenium ion intermediate (sigma complex).
- Loss of a proton regenerates the aromatic sextet, producing chlorobenzene via electrophilic substitution.

Why other options are incorrect:

- Option A:** Electrophilic addition would permanently disrupt the aromatic ring's resonance stability.
- Option C:** Free radical substitution occurs in alkanes or alkyl side chains under UV light, not on the aromatic ring with a Lewis acid.
- Option D:** Free radical halogenation requires UV illumination or peroxides, producing addition products like hexachlorocyclohexane.

Question #125 Key: (D)

CHEMISTRY
11. S & P Block Elements

The element with smallest value of Ionization energy is

CORE CONCEPT & DERIVATION

First ionization energy decreases down an elemental group as atomic radius increases and inner electron shells shield the valence electrons from nuclear attraction.

Formula / Rule / Reaction:

$$\text{Ionization Energy} \propto \frac{Z_{\text{eff}}}{n} \implies \text{Decreases Down a Group as Principal Quantum Number } n \text{ Increases}$$

Solution:

- Barium (Ba) is a period 6 alkaline earth metal (Group 2).
- Its outermost valence electrons reside in the $6s$ subshell, far from the nucleus and heavily shielded by 54 inner core electrons.
- Consequently, Ba holds its valence electrons loosely, giving it the lowest ionization energy (503 kJ/mol) among the options.

Why other options are incorrect:

- Option A:** Lithium (Li) is in Period 2 with minimal shielding, giving it a higher ionization energy (520 kJ/mol).
- Option B:** Aluminum (Al) is a Period 3 p -block element with an ionization energy of 578 kJ/mol.
- Option C:** Calcium (Ca) is in Period 4 of Group 2; being higher in the group than barium, its ionization energy is higher (590 kJ/mol).

Question #126 Key: (D)

CHEMISTRY
18. Carboxylic Acids

Carboxylic acid reacts with ammonia to form ammonium salts which on heating produces

CORE CONCEPT & DERIVATION

Ammonium carboxylate salts undergo thermal dehydration upon strong heating, losing a molecule of water to yield primary acid amides.

Formula / Rule / Reaction:



Solution:

- Carboxylic acids react with basic ammonia in an acid-base neutralization to form ammonium carboxylate salts ($\text{R-COO}^- \text{NH}_4^+$).
- Heating this salt drives off water (H_2O), converting the ionic salt into a covalent primary amide (R-CONH_2).

Why other options are incorrect:

- Option A:** Carbonates contain the CO_3^{2-} ion and do not form from the thermal dehydration of carboxylic acid salts.
- Option B:** Alkanes are produced by decarboxylation of carboxylate salts with soda lime, not by heating with ammonia.
- Option C:** Esters are formed by reacting carboxylic acids with alcohols in the presence of an acid catalyst.

Question #127 Key: (B)PHYSICS
03. Work & Energy

If P is the momentum of an object and m is its mass, then its kinetic energy is:

CORE CONCEPT & DERIVATION

Kinetic energy and linear momentum are both functions of an object's mass and velocity, allowing kinetic energy to be expressed directly in terms of momentum.

Formula / Rule / Reaction:

$$P = mv \implies v = \frac{P}{m}$$

$$K = \frac{1}{2}mv^2 = \frac{1}{2}m\left(\frac{P}{m}\right)^2 = \frac{P^2}{2m}$$

Solution:

- Substitute the definition of velocity $v = P/m$ into the classical kinetic energy expression $K = \frac{1}{2}mv^2$.
- Simplifying yields $K = \frac{P^2}{2m}$.

Why other options are incorrect:

- Option A:** Lacks the required square on momentum, which is dimensionally inconsistent with energy.
- Option C:** Inverts the dimensional relationship between mass and momentum.
- Option D:** Places mass in the numerator rather than the denominator, which is dimensionally incorrect.

Question #128 Key: (C)PHYSICS
08. Electrostatics

The electric field at a point due to two equal and opposite charges is 100 N/C. If the magnitude...

CORE CONCEPT & DERIVATION

By the principle of linear superposition, the total electric field at any point in space is the vector sum of the individual electric fields, each of which is directly proportional to its source charge.

Formula / Rule / Reaction:

$$\vec{E}_{\text{net}} = \vec{E}_1 + \vec{E}_2 = k\frac{q_1}{r_1^2}\hat{r}_1 + k\frac{q_2}{r_2^2}\hat{r}_2 \implies \vec{E}_{\text{net}} \propto q$$

Solution:

- Let the initial charges be $+q$ and $-q$, producing an initial net field $E_{\text{initial}} = 100 \text{ N/C}$.
- When the magnitude of each charge is doubled ($q' = 2q$), each individual electric field vector doubles in magnitude:

$$\vec{E}'_{\text{net}} = 2\vec{E}_1 + 2\vec{E}_2 = 2(\vec{E}_1 + \vec{E}_2) = 2\vec{E}_{\text{net}}$$

- Therefore, the new net electric field is $2 \times 100 \text{ N/C} = 200 \text{ N/C}$.
- Board Erratum Note:** Certain unofficial keys incorrectly marked 400 N/C by confusing electric field with Coulomb force (which depends on the product of two charges, $F \propto q_1q_2$). Electric field intensity is strictly linear with respect to charge magnitude.

Why other options are incorrect:

- Option A:** 50 N/C implies that doubling charge halves the field, contradicting direct proportionality.
- Option B:** 100 N/C assumes field strength is independent of source charge magnitude.
- Option D:** 400 N/C incorrectly applies Coulomb's force law ($F \propto q_1q_2$) instead of the linear electric field relation ($E \propto q$).

Question #129 Key: (B)PHYSICS
08. Electrostatics

If a plastic sheet of relative permittivity 2.5 is inserted between two point charges placed in...

CORE CONCEPT & DERIVATION

Coulomb's electrostatic force between two point charges in a medium is reduced relative to a vacuum by a factor equal to the dielectric constant (relative permittivity, ϵ_r) of the material.

Formula / Rule / Reaction:

$$F_{\text{med}} = \frac{F_{\text{vac}}}{\epsilon_r}$$

Solution:

- The dielectric material undergoes polarization in the electric field, creating an opposing internal field that weakens the net field between the charges.
- Substituting $\epsilon_r = 2.5$ shows that the electrostatic force becomes $F_{\text{med}} = \frac{F_{\text{vac}}}{2.5}$.
- Thus, the electrostatic force decreases by a factor of 2.5.

Why other options are incorrect:

- Option A:** Placing a dielectric between charges reduces the electric field; it cannot increase the force.
- Option C:** Dielectrics screen and diminish electrostatic interactions rather than increasing them.
- Option D:** The factor of reduction is exactly $\epsilon_r = 2.5$, not 5.

Question #130 Key: (C)PHYSICS
16. Nuclear Physics

After 3 half-lives, the remaining fraction of a radioactive sample is:

CORE CONCEPT & DERIVATION

Radioactive decay follows first-order kinetics, meaning the fraction of undecayed parent nuclei remaining after n half-lives decreases by a factor of $(1/2)^n$.

Formula / Rule / Reaction:

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^n$$

Solution:

- For $n = 3$ half-lives:

$$\frac{N}{N_0} = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$$

- Therefore, one-eighth of the original radioactive nuclei remain undecayed.

Why other options are incorrect:

- Option A:** $1/2$ is the fraction remaining after 1 half-life.
- Option B:** $1/4$ is the fraction remaining after 2 half-lives.
- Option D:** $1/16$ is the fraction remaining after 4 half-lives.

Question #131 Key: (A)PHYSICS
02. Force & Motion

If the horizontal range of a projectile becomes half of its maximum possible horizontal range, ...

CORE CONCEPT & DERIVATION

The horizontal range of a projectile fired on level ground depends on launch speed and angle, reaching its theoretical maximum when $\theta = 45^\circ$.

Formula / Rule / Reaction:

$$R = \frac{v_0^2 \sin(2\theta)}{g}, \quad R_{\max} = \frac{v_0^2}{g}$$

Solution:

- Set the horizontal range equal to half the maximum range:

$$R = \frac{1}{2} R_{\max} \Rightarrow \frac{v_0^2 \sin(2\theta)}{g} = \frac{1}{2} \left(\frac{v_0^2}{g} \right)$$

$$\sin(2\theta) = \frac{1}{2}$$

- Solving for the launch angle:

$$2\theta = 30^\circ \Rightarrow \theta = 15^\circ \quad (\text{or complementary angle } 75^\circ)$$

- Therefore, the launch angle is 15° .

Why other options are incorrect:

- Option B:** At $\theta = 30^\circ$, $\sin(2\theta) = \sin(60^\circ) = \frac{\sqrt{3}}{2} \approx 0.866$ of maximum range.
- Option C:** At $\theta = 45^\circ$, $\sin(90^\circ) = 1$, yielding the maximum possible range.
- Option D:** At $\theta = 60^\circ$, $\sin(120^\circ) = \frac{\sqrt{3}}{2} \approx 0.866$ of maximum range.

Question #132 Key: (A)PHYSICS
11. Electromagnetic Induction

In an ideal transformer, if the primary voltage is doubled and the turns ratio remains the same...

CORE CONCEPT & DERIVATION

In an ideal transformer connected to a constant secondary load resistance, secondary voltage is directly proportional to primary voltage, which in turn determines secondary current via Ohm's law.

Formula / Rule / Reaction:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \Rightarrow V_s = V_p \left(\frac{N_s}{N_p} \right), \quad I_s = \frac{V_s}{R_L}$$

Solution:

- Because the turns ratio $\frac{N_s}{N_p}$ is constant, doubling the primary voltage V_p doubles the secondary voltage V_s .
- Across a fixed secondary load resistance R_L , Ohm's law ($I_s = V_s / R_L$) dictates that doubling V_s causes the secondary current I_s to double as well.

Why other options are incorrect:

- Option B:** The secondary current would halve only if the secondary voltage were halved.
- Option C:** Secondary current cannot remain unchanged when secondary induced electromotive force has doubled across a constant load.
- Option D:** Current increases linearly with voltage across an ohmic load, not quadrupled.

Question #133 Key: (A)PHYSICS
04. Rotational & Circular Motion

An angular displacement of 90° is equal to:

CORE CONCEPT & DERIVATION

Angular displacement measures circular rotation, where one complete revolution spans an angle of 360° (or 2π radians).

Formula / Rule / Reaction:

$$\text{Revolutions} = \frac{\theta(^{\circ})}{360^{\circ}}$$

Solution:

- Substitute $\theta = 90^\circ$ into the conversion equation:

$$\text{Revolutions} = \frac{90^{\circ}}{360^{\circ}} = \frac{1}{4} \text{ revolution}$$

- Thus, 90° corresponds to one-fourth of a complete revolution.

Why other options are incorrect:

- Option B:** One-third revolution corresponds to $\frac{360^{\circ}}{3} = 120^\circ$.
- Option C:** One-half revolution corresponds to $\frac{360^{\circ}}{2} = 180^\circ$.
- Option D:** One complete revolution corresponds to 360° .

Question #134 Key: (A)PHYSICS
16. Nuclear Physics

The time in which half of the given number of radioactive nuclei decay is known as

CORE CONCEPT & DERIVATION

The half-life ($T_{1/2}$) of a radioactive nuclide is the characteristic time required for half of the unstable radioactive nuclei in a given sample to undergo decay.

Formula / Rule / Reaction:

$$T_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda}$$

Solution:

- Radioactive decay is a spontaneous nuclear process governed by an exponential decay law.
- The time required for the initial activity (or parent nucleus count N_0) to reduce to $\frac{N_0}{2}$ is defined as the half-life.

Why other options are incorrect:

- Option B:** Two-thirds life is not a standard physical parameter in nuclear physics.
- Option C:** Three-quarters life describes the duration for 75% of the sample to decay (which takes two half-lives).
- Option D:** Two-fifths life has no definition in nuclear kinetics.

Question #135 Key: (C)

PHYSICS
13. Electronics

Earth receives large amount of energy directly from:

CORE CONCEPT & DERIVATION

Solar irradiance from the Sun is Earth's primary extraterrestrial source of energy, powering atmospheric circulation, the hydrological cycle, and biological photosynthesis.

Formula / Rule / Reaction:

$$\text{Solar Constant} \approx 1.361 \text{ kW/m}^2 \quad (\text{Radiant Flux Incident on Upper Atmosphere})$$

Solution:

- Nuclear fusion reactions in the Sun's core release immense quantities of radiant electromagnetic energy.
- This solar radiation travels through the vacuum of space to reach Earth, providing the primary thermodynamic driving force for terrestrial ecosystems.

Why other options are incorrect:

- **Option A:** Wind is a secondary kinetic energy form generated by solar-driven atmospheric temperature and pressure gradients.
- **Option B:** Water currents and hydrological cycles are secondary mechanical manifestations powered by solar heating and gravity.
- **Option C:** The Moon provides negligible thermal energy to Earth, contributing primarily gravitational tidal forces.

Question #136 Key: (B)

PHYSICS
12. Alternating Current

A phase difference of [Formula] is equal to:

CORE CONCEPT & DERIVATION

Angular phase in harmonic wave motion converts from degrees to radians by multiplying by the conversion factor $\frac{\pi \text{ rad}}{180^\circ}$.

Formula / Rule / Reaction:

$$\theta \text{ (radians)} = \theta \text{ (degrees)} \times \frac{\pi}{180^\circ}$$

Solution:

- Substitute $\theta = 90^\circ$ into the angular conversion relation:

$$\theta = 90^\circ \times \frac{\pi}{180^\circ} = \frac{\pi}{2} \text{ radians}$$

- Therefore, a 90° phase difference is equivalent to $\pi/2$ radians.

Why other options are incorrect:

- **Option A:** π radians corresponds to an angular phase difference of 180° .
- **Option C:** 2π radians corresponds to a complete cycle of 360° .
- **Option D:** $\pi/4$ radians corresponds to an angle of 45° .

Question #137 Key: (B)

PHYSICS
13. Electronics

The reciprocal of the resistivity of a material is called its:

CORE CONCEPT & DERIVATION

Electrical conductivity (σ) is an intrinsic material property defined as the mathematical reciprocal of electrical resistivity (ρ).

Formula / Rule / Reaction:

$$\sigma = \frac{1}{\rho} \quad (\text{SI Unit: } \Omega^{-1} \cdot \text{m}^{-1} \text{ or Siemens per meter, S/m})$$

Solution:

- Resistivity measures a material's opposition to the flow of electric current.
- Conductivity quantifies the ease with which charge carriers drift through the material under an applied electric field.
- By definition, conductivity is the reciprocal of resistivity.

Why other options are incorrect:

- **Option A:** Impedance (Z) is the total effective opposition of an alternating current circuit containing resistance and reactance.
- **Option C:** Admittance (Y) is the reciprocal of impedance ($Y = 1/Z$), representing total AC current ease.
- **Option D:** Reactance (X) is the non-resistive opposition to AC current arising from inductance or capacitance.

Question #138 Key: (D)

PHYSICS
15. Atomic Spectra

The Balmer series of hydrogen spectrum appears in the:

CORE CONCEPT & DERIVATION

The Balmer series comprises electronic de-excitations in atomic hydrogen terminating at the second principal energy level ($n_f = 2$).

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{2^2} - \frac{1}{n_i^2} \right) \quad \text{where } n_i \in \{3, 4, 5, 6, \dots\}$$

Solution:

- Transitions from $n_i = 3, 4, 5, 6$ to $n_f = 2$ emit photons with wavelengths ranging between 364.6 nm and 656.3 nm.
- This wavelength band falls directly within the visible spectrum of electromagnetic radiation.

Why other options are incorrect:

- **Option A:** The Paschen, Brackett, and Pfund series fall in the infrared region.
- **Option B:** The Lyman series (transitions terminating at $n_f = 1$) appears in the ultraviolet region.
- **Option C:** Inner-shell transitions in heavy transition elements emit high-energy X-rays, not hydrogen transitions.

Question #139 Key: (D)

PHYSICS
02. Force & Motion

A ball is thrown into the air with certain velocity [Formula] making an angle [Formula] with horizontal.

CORE CONCEPT & DERIVATION

In two-dimensional projectile motion under uniform gravity without air resistance, the horizontal velocity component remains constant while the vertical component varies continuously.

Formula / Rule / Reaction:

$$v_x = v_0 \cos \theta = \text{constant}, \quad v_y = 0 \text{ at peak} \implies v_{\text{peak}} = \sqrt{v_x^2 + 0^2} = v_0 \cos \theta$$

Solution:

- At the apex of the parabolic trajectory, upward vertical motion ceases instantaneously, so $v_y = 0$.
- The horizontal velocity component $v_x = v_0 \cos \theta$ persists completely unchanged because no horizontal force acts on the projectile.
- Consequently, total velocity at the summit reaches its minimum value ($v_0 \cos \theta$), which is non-zero for any launch angle $0^\circ < \theta < 90^\circ$.

Why other options are incorrect:

- Option A:** Total velocity equals the initial launch speed only upon return to the initial launch elevation.
- Option B:** The velocity at the peak equals half the initial velocity only if $\cos \theta = 0.5$ (launch angle of 60°), not in the general case.
- Option C:** Velocity becomes zero at the summit only for a purely vertical projection ($\theta = 90^\circ$).

Question #140 Key: (C)

PHYSICS
02. Force & Motion

A cannon is placed on a smooth surface. When it fires a shell, the cannon moves backward. This ...

CORE CONCEPT & DERIVATION

According to Newton's Third Law of Motion, every action force is accompanied by an equal and opposite reaction force between interacting bodies.

Formula / Rule / Reaction:

$$\vec{F}_{\text{cannon on shell}} = -\vec{F}_{\text{shell on cannon}} \implies \Delta \vec{P}_{\text{system}} = 0$$

Solution:

- The expanding propellant gases exert a large forward force on the projectile shell.
- Simultaneously, the shell exerts an equal force in the opposite direction on the cannon breech.
- This backward reaction force accelerates the cannon rearward across the smooth surface, producing recoil.

Why other options are incorrect:

- Option A:** Conservation of energy tracks energy transformations (chemical to kinetic and heat), but does not identify the mechanical force causing recoil.
- Option B:** Propellant gas expansion drives the projectile forward, but the mutual contact reaction between the shell and the cannon is governed by Newton's third law.
- Option D:** Newton's first law defines inertia and reference frames, not the mutual action-reaction pair.

Question #141 Key: (A)

PHYSICS
08. Electrostatics

If the surface charge density of an infinite sheet increases by 25%, the electric field intensity...

CORE CONCEPT & DERIVATION

The electric field intensity near an infinite plane sheet of charge is directly proportional to its surface charge density.

Formula / Rule / Reaction:

$$E = \frac{\sigma}{2\epsilon_0} \implies E \propto \sigma$$

Solution:

- Let the initial charge density be σ and initial electric field be E .
- When the surface charge density increases by 25%, the new density becomes $\sigma' = 1.25\sigma$.
- Because ϵ_0 is a universal physical constant, the new electric field is:

$$E' = \frac{\sigma'}{2\epsilon_0} = \frac{1.25\sigma}{2\epsilon_0} = 1.25E$$

- This corresponds to an increase of exactly 25% in the electric field intensity.

Why other options are incorrect:

- Option B:** 50% would require the surface charge density to increase by 50%.
- Option C:** A decrease by 25% would require charge removal, not addition.
- Option D:** The electric field intensity cannot remain constant when the source charge density on the sheet changes.

Question #142 Key: (C)

PHYSICS
06. Fluid Dynamics

An incompressible fluid flows through a pipe that becomes narrower in one section. The fluid speed...

CORE CONCEPT & DERIVATION

The continuity equation for the steady flow of an incompressible fluid is a mathematical expression of the law of conservation of mass.

Formula / Rule / Reaction:

$$\frac{dm}{dt} = \rho A v = \text{constant} \implies A_1 v_1 = A_2 v_2$$

Solution:

- For an incompressible fluid, density (ρ) is constant throughout the flow.
- Mass conservation dictates that the mass entering any cross section per second must equal the mass exiting per second.
- When the cross-sectional area (A) decreases, the flow velocity (v) must increase proportionally to maintain a constant mass flow rate.

Why other options are incorrect:

- Option A:** Fluid pressure decreases in the narrower region due to Bernoulli's effect; it is not constant.
- Option B:** While total mechanical energy is conserved along a streamline, velocity increases specifically to maintain mass continuity.
- Option D:** Volume refers to a static capacity, whereas dynamic fluid continuity maintains the volumetric and mass flow rate per unit time.

Question #143 Key: (B)PHYSICS
06. Fluid Dynamics

In a pipe of varying cross-section, as fluid enters the narrower region, it exhibits:

CORE CONCEPT & DERIVATION

According to the equation of continuity, fluid accelerates in a constriction, and by Bernoulli's principle, an increase in fluid speed is accompanied by a simultaneous drop in static pressure.

Formula / Rule / Reaction:

$$A_1 v_1 = A_2 v_2, \quad P + \frac{1}{2} \rho v^2 + \rho g h = \text{constant}$$

Solution:

- As cross-sectional area decreases in the narrow constriction, the velocity of the fluid must increase (high velocity).
- Bernoulli's equation states that for horizontal streamline flow, the sum of static pressure and dynamic pressure is constant:

$$P_2 = P_1 - \frac{1}{2} \rho (v_2^2 - v_1^2)$$

- Because $v_2 > v_1$, static pressure P_2 must decrease (low pressure).
- Therefore, the fluid exhibits high velocity and low pressure.

Why other options are incorrect:

- Option A:** High velocity cannot coexist with high pressure in horizontal streamline flow because dynamic pressure increases at the expense of static pressure.
- Option C:** Low velocity occurs in wider sections of the pipe, not narrower sections.
- Option D:** While pressure drops, velocity increases rather than decreasing.

Question #144 Key: (B)PHYSICS
13. Electronics

The curved shape of an airplane wing causes air to move faster over the top surface. This leads...

CORE CONCEPT & DERIVATION

Bernoulli's principle establishes that regions of higher fluid velocity experience lower static pressure, producing aerodynamic lift across asymmetric aerofoils.

Formula / Rule / Reaction:

$$v_{\text{top}} > v_{\text{bottom}} \implies P_{\text{top}} < P_{\text{bottom}} \implies F_{\text{lift}} = (P_{\text{bottom}} - P_{\text{top}})A$$

Solution:

- The cambered upper surface of an airplane wing forces air streamlines to converge and travel faster over the top.
- By Bernoulli's theorem, higher speed reduces the static pressure exerted by the air on the upper surface.
- The higher pressure beneath the wing generates an upward net force (aerodynamic lift).

Why other options are incorrect:

- Option A:** Faster airflow lowers static pressure; it does not increase it.
- Option C:** Equal pressure would yield zero pressure differential, generating no lift.
- Option D:** Static pressure decreases relative to ambient levels, but it does not drop to absolute vacuum (zero pressure).

Question #145 Key: (D)PHYSICS
16. Nuclear Physics

The protons in the nucleus of an atom do not exit out due to the:

CORE CONCEPT & DERIVATION

The strong nuclear force is a short-range, powerful fundamental interaction that overcomes mutual electrostatic repulsion between positively charged protons to bind nucleons within the atomic nucleus.

Formula / Rule / Reaction:

$$F_{\text{strong}} \gg F_{\text{Coulomb}} \quad (\text{acting over distances } r \leq 10^{-15} \text{ m})$$

Solution:

- Protons carry positive charges and experience repulsive Coulomb forces at nuclear separations.
- The strong nuclear force is approximately 100 times stronger than the electromagnetic repulsion at femtometer distances.
- This strong attractive interaction acts equally between protons and neutrons, holding the nucleus together.

Why other options are incorrect:

- Option A:** The electromagnetic force causes mutual repulsion between like positive charges, which would push protons apart.
- Option B:** Gravitational attraction between nucleon masses is 10^{36} times weaker than the electrostatic repulsion and is negligible.
- Option C:** The weak nuclear force governs beta decay and neutrino interactions; it does not provide nuclear binding.

Question #146 Key: (D)PHYSICS
05. Waves

Mechanical waves cannot travel through outer space because they:

CORE CONCEPT & DERIVATION

Mechanical waves (such as sound and seismic waves) require a physical material medium containing interacting elastic particles to propagate energy.

Formula / Rule / Reaction:

$$v = \sqrt{\frac{E}{\rho}} \quad (\text{Propagation requires Elastic Modulus } E > 0 \text{ and Density } \rho > 0)$$

Solution:

- Mechanical wave transmission relies on the transfer of momentum and energy between adjacent particles in a medium.
- Outer space is an interstellar vacuum devoid of a continuous material medium.
- Without matter particles to oscillate and collide, mechanical waves cannot propagate.

Why other options are incorrect:

- Option A:** The speed of mechanical waves in a vacuum is zero, not a non-zero low value.
- Option B:** Dispersion relates to frequency-dependent velocity in a medium, not the absence of a medium.
- Option C:** Wave frequency is determined by the source and does not change simply due to the absence of surrounding air.

Question #147 Key: (A)PHYSICS
09. Current Electricity

The terminal voltage of a cell equals its EMF only when:

CORE CONCEPT & DERIVATIONThe terminal potential difference (V_t) across a real voltage source differs from its electromotive force (E) by the internal resistance voltage drop (Ir).

Formula / Rule / Reaction:

$$V_t = E - Ir$$

Solution:

- When an external circuit is open, no current flows ($I = 0$).
- Substituting $I = 0$ into the terminal voltage equation:

$$V_t = E - (0)(r) = E$$

- Therefore, terminal voltage equals EMF when no current is drawn from the cell.

Why other options are incorrect:

- Option B:** When current is maximum (short-circuit condition), the internal drop Ir is maximal and terminal voltage drops to zero.
- Option C:** Infinite internal resistance describes an open-circuit defect, but the operational condition is having zero current flow.
- Option D:** Zero load resistance short-circuits the cell, causing terminal voltage to drop to zero.

Question #148 Key: (B)PHYSICS
11. Electromagnetic Induction

If a loop moves toward a stationary magnet, the induced current will:

CORE CONCEPT & DERIVATION

Lenz's Law, rooted in the conservation of energy, states that an induced current always flows in such a direction that its magnetic field opposes the change in magnetic flux that produced it.

Formula / Rule / Reaction:

$$E = -\frac{d\Phi_B}{dt}$$

Solution:

- As the conducting loop approaches the stationary magnet, magnetic flux through the loop increases.
- By Lenz's law, the induced current creates an opposing magnetic field with like magnetic polarity facing the incoming magnet.
- This creates a repulsive magnetic force that opposes the motion and tries to stop the approach.

Why other options are incorrect:

- Option A:** Enhancing the motion would accelerate the loop without work input, violating the law of conservation of energy.
- Option C:** A non-zero current is induced as long as relative motion changes the magnetic flux.
- Option D:** Unidirectional approach produces a direct induced current in one direction, not an alternating current.

Question #149 Key: (D)PHYSICS
05. Waves

The energy of a Simple Harmonic oscillation depends upon the

CORE CONCEPT & DERIVATION

The total mechanical energy of an ideal simple harmonic oscillator is directly proportional to the square of its displacement amplitude.

Formula / Rule / Reaction:

$$E_{\text{total}} = \frac{1}{2}kx_0^2 = \frac{1}{2}m\omega^2 x_0^2$$

Solution:

- In a simple harmonic system with a given spring constant k , potential energy reaches its maximum at the extreme displacement (amplitude x_0).
- Because total energy is conserved, $E_{\text{total}} = \frac{1}{2}kx_0^2$.
- Thus, the total energy stored in the oscillator depends directly on its amplitude.

Why other options are incorrect:

- Option A:** For a fixed oscillator, frequency is set by mass and stiffness; amplitude determines how much energy is put into the oscillation.
- Option B:** Time period is an intrinsic property independent of amplitude and stored energy in linear simple harmonic motion.
- Option C:** Wavelength is a property of traveling spatial waves, not a single localized harmonic oscillator.

Question #150 Key: (C)PHYSICS
12. Alternating Current

The wave that has the highest frequency and penetrating power is

CORE CONCEPT & DERIVATION

In the electromagnetic spectrum, photon energy and penetrating capability are directly proportional to wave frequency and inversely proportional to wavelength.

Formula / Rule / Reaction:

$$E = h\nu = \frac{hc}{\lambda} \implies \nu > 10^{19} \text{ Hz for Gamma Rays}$$

Solution:

- Gamma rays originate from nuclear transitions and possess the shortest wavelengths ($< 10^{-12} \text{ m}$) and highest frequencies in the electromagnetic spectrum.
- Their high photon energy enables them to penetrate deeply through matter, requiring dense lead shielding to attenuate.

Why other options are incorrect:

- Option A:** X-rays have lower frequencies ($10^{16} - 10^{19} \text{ Hz}$) and less penetrating power than gamma rays.
- Option B:** Ultraviolet rays have much lower frequencies and are stopped by ordinary glass or the epidermis.
- Option D:** Microwaves have long wavelengths (millimeter to centimeter range) and very low photon energies.

Question #151 Key: (A)PHYSICS
07. Thermodynamics

According to First law of thermodynamics when heat flows into a system and no work is done, the...

CORE CONCEPT & DERIVATION

The First Law of Thermodynamics states that the net heat absorbed by a system changes its internal energy when no work is exchanged with the surroundings.

Formula / Rule / Reaction:

$$\Delta U = Q - W \quad (\text{or } \Delta U = Q + W)$$

Solution:

- Heat added to the system is positive ($Q > 0$).
- Because no boundary work is performed, $W = 0$.
- Therefore, $\Delta U = Q > 0$, meaning the internal energy of the system must increase.

Why other options are incorrect:

- Option B:** Internal energy would decrease only if heat were extracted from the system or if the system performed expansion work.
- Option C:** Internal energy remains constant only during an isothermal process where heat added is balanced by work done.
- Option D:** Internal energy represents the total molecular kinetic and potential energies, which cannot drop to zero when heat is added.

Question #152 Key: (D)PHYSICS
09. Current Electricity

If the length of the conductor is made 4 times its original length, its resistance becomes

CORE CONCEPT & DERIVATION

The electrical resistance of a uniform conductor is directly proportional to its length when resistivity and cross-sectional area are held constant.

Formula / Rule / Reaction:

$$R = \rho \frac{L}{A} \implies R \propto L$$

Solution:

- Let the initial resistance be $R = \rho \frac{L}{A}$.
- When the conductor length is increased to four times its original length ($L' = 4L$) at constant cross-sectional area:

$$R' = \rho \frac{4L}{A} = 4\left(\rho \frac{L}{A}\right) = 4R$$

- Thus, the electrical resistance becomes 4 times its original value.

Why other options are incorrect:

- Option A:** Quarter would occur if length were reduced to $L/4$.
- Option B:** Half would occur if length were halved.
- Option C:** Resistance cannot drop to zero in an ohmic conductor.

Question #153 Key: (B)PHYSICS
09. Current Electricity

The unit of temperature coefficient of resistivity is

CORE CONCEPT & DERIVATION

The temperature coefficient of resistivity (α) is defined as the fractional change in resistivity per degree change in absolute temperature.

Formula / Rule / Reaction:

$$\alpha = \frac{\rho_T - \rho_0}{\rho_0 \Delta T} = \frac{\Delta \rho}{\rho_0 \Delta T}$$

Solution:

- Resistivity (ρ) in the numerator and reference resistivity (ρ_0) in the denominator both have units of $\Omega \cdot \text{m}$, which cancel out.
- This leaves the unit of α as the reciprocal of temperature: $\frac{1}{\text{Kelvin}} = \text{K}^{-1}$.
- In the SI system, the unit is expressed as $1/\text{K}$ (or K^{-1}).

Why other options are incorrect:

- Option A:** While $1/^{\circ}\text{C}$ is numerically identical for temperature differences, the SI base unit of thermodynamic temperature is the Kelvin ($1/\text{K}$).
- Option C:** $1/\text{A}$ is reciprocal electric current.
- Option D:** $1/\Omega$ (Siemens) is the unit of electrical conductance, not temperature coefficient.

Question #154 Key: (B)PHYSICS
03. Work & Energy

The work done by the gravitational force on an object as it moves from a reference level to a h...

CORE CONCEPT & DERIVATION

Work done by a constant force is the scalar dot product of the force vector and the displacement vector.

Formula / Rule / Reaction:

$$W_g = \vec{F}_g \cdot \Delta \vec{r} = mgh \cos(180^{\circ}) = -mgh$$

Solution:

- The gravitational force vector points vertically downward toward Earth's center ($\vec{F}_g = -mg\hat{j}$).
- When an object moves to a higher elevation, its vertical displacement vector points upward ($\Delta \vec{r} = +h\hat{j}$).
- The angle between the downward gravitational force and upward displacement is 180° .
- Because $\cos(180^{\circ}) = -1$, the work done by gravity is always negative.

Why other options are incorrect:

- Option A:** Gravitational work is positive only when an object moves downward in the direction of the gravitational force.
- Option C:** Work is zero only if there is no vertical displacement or if motion is purely horizontal.
- Option D:** Gravity is a conservative force; its work depends solely on the initial and final heights, not the path taken.

Question #155 **Key: (B)**PHYSICS
05. Waves

If two speakers emit sound at same frequency and phase, maximum loudness occurs when:

CORE CONCEPT & DERIVATION

Constructive interference producing maximum acoustic intensity (loudness) occurs when the path difference between two coherent in-phase sources is an integral multiple of the wavelength.

Formula / Rule / Reaction:

$$\Delta x = n\lambda \quad \text{where } n \in \{0, 1, 2, 3, \dots\} \quad (\text{Constructive Interference})$$

Solution:

- When two speakers emit sound in phase, their waves arrive at a point in phase if their path difference equals an integer number of wavelengths ($n = 1 \Rightarrow \Delta x = \lambda$).
- Wave crests align with wave crests, doubling the resultant amplitude and producing maximum loudness.

Why other options are incorrect:

- Option A:** A path difference of $\lambda/2$ causes destructive interference, where crests meet troughs to produce a point of minimum loudness.
- Option C:** $\lambda/4$ yields an intermediate phase difference of 90° , producing partial, non-maximal loudness.
- Option D:** $3\lambda/4$ yields a phase difference of 270° , producing partial destructive interference.

Question #156 **Key: (B)**PHYSICS
06. Fluid Dynamics

When an object attains terminal velocity, its acceleration is:

CORE CONCEPT & DERIVATION

Terminal velocity is the constant maximum speed reached by an object falling through a resistive fluid when drag force balances downward gravitational force.

Formula / Rule / Reaction:

$$\Sigma F = F_g - F_d = mg - 6\pi\eta r v_t = 0 \Rightarrow a = \frac{\Sigma F}{m} = 0$$

Solution:

- As an object falls, air drag increases proportionally with velocity until it equals the downward gravitational force.
- When drag balances weight, the net external force on the object becomes zero.
- By Newton's second law ($a = \Sigma F/m$), zero net force produces zero acceleration, and the object continues at constant terminal velocity.

Why other options are incorrect:

- Option A:** 9.8 m/s^2 is the acceleration in free fall in a vacuum, where drag is absent.
- Option C:** Any non-zero acceleration means velocity is still changing, which cannot occur at terminal velocity.
- Option D:** 9.8 m/s has units of speed, not acceleration.

Question #157 **Key: (A)**PHYSICS
02. Force & Motion

A 0.5 kg ball moving at 6 m/s has kinetic energy

CORE CONCEPT & DERIVATION

Translational kinetic energy is calculated as half the product of an object's mass and the square of its velocity.

Formula / Rule / Reaction:

$$K = \frac{1}{2}mv^2$$

Solution:

- Given values: $m = 0.5 \text{ kg}$ and $v = 6 \text{ m/s}$.
- Substitute these values into the kinetic energy equation:

$$K = \frac{1}{2}(0.5 \text{ kg})(6 \text{ m/s})^2 = 0.25 \times 36 = 9 \text{ J}$$

- Therefore, the kinetic energy is 9 J.

Why other options are incorrect:

- Option B:** 18 J omits the factor of $1/2$ (0.5×36).
- Option C:** 6 J miscalculates the relationship between mass and squared velocity.
- Option D:** 3 J calculates $m \times v = 0.5 \times 6$, which is momentum, not kinetic energy.

Question #158 **Key: (C)**PHYSICS
06. Fluid Dynamics

A fluid is flowing through a tube, to undergo transition from laminar to turbulent flow it's ve...

CORE CONCEPT & DERIVATION

The transition from smooth laminar streamline flow to chaotic turbulent flow occurs when fluid flow velocity exceeds the critical velocity, corresponding to a critical Reynolds number.

Formula / Rule / Reaction:

$$N_R = \frac{\rho v D}{\eta} \Rightarrow v_c = \frac{N_{R,critical} \eta}{\rho D}$$

Solution:

- At flow speeds below critical velocity ($v < v_c$), viscous forces dominate and the fluid moves in smooth, parallel lamina.
- When velocity exceeds this threshold ($v > v_c$), inertial forces destabilize the streamlines, producing eddies and turbulence.

Why other options are incorrect:

- Option A:** Velocities below critical velocity maintain steady laminar flow.
- Option B:** At critical velocity, the flow is at the threshold of instability, but full turbulence requires exceeding this value.
- Option D:** Flow remains laminar as long as velocity stays below the critical threshold.

Question #159 Key: (A)PHYSICS
08. Electrostatics

For two equal positive charges, the electric field weakest?

CORE CONCEPT & DERIVATION

The net electric field at any point in space is the vector sum of the fields produced by individual source charges.

Formula / Rule / Reaction:

$$\vec{E}_{\text{net}} = \vec{E}_1 + \vec{E}_2 = k \frac{q}{r^2} \hat{r}_1 + k \frac{q}{r^2} \hat{r}_2$$

Solution:

- Midway along the line connecting two identical positive charges $+q$, the distance to each charge is equal.
- The electric field vector from the left charge points to the right, while the field vector from the right charge points to the left with equal magnitude.
- The two opposing vectors cancel each other out completely:

$$\vec{E}_{\text{midway}} = E\hat{i} - E\hat{i} = 0$$

- Thus, the electric field is weakest (zero) midway between them.

Why other options are incorrect:

- Option B:** Along the perpendicular bisector, horizontal components cancel but vertical components add constructively to give a non-zero net field.
- Option C:** Close to either charge, the inverse-square distance term makes the local field very strong.
- Option D:** While the field approaches zero at infinity, within the local region surrounding the charges, the point of zero field is midway between them.

Question #160 Key: (A)PHYSICS
02. Force & Motion

A projectile is launched in air with certain angle; its velocity is maximum at:

CORE CONCEPT & DERIVATION

In projectile motion under conservative gravity, mechanical energy is conserved, meaning kinetic energy (and speed) is highest where gravitational potential energy is lowest.

Formula / Rule / Reaction:

$$E_{\text{mech}} = \frac{1}{2}mv^2 + mgh = \text{constant} \implies v = \sqrt{v_0^2 - 2gh}$$

Solution:

- At the point of projection, the vertical height is at its baseline ($h = 0$), so gravitational potential energy is at its minimum.
- By conservation of energy, kinetic energy is at its maximum at launch, so velocity is at its highest value ($v = v_0$).
- As the projectile ascends, vertical speed decreases due to gravity, reaching a minimum at the trajectory apex.

Why other options are incorrect:

- Option B:** At the highest point, potential energy is maximal and vertical velocity is zero, making speed a minimum ($v = v_0 \cos \theta$).
- Option C:** Between launch and peak, the projectile has already decelerated vertically, so its speed is lower than at launch.
- Option D:** Velocity varies continuously as gravity acts on the vertical velocity component.

Question #161 Key: (D)PHYSICS
08. Electrostatics

If the distance between two charges is halved and magnitude of charges are also doubled, then t...

CORE CONCEPT & DERIVATION

According to Coulomb's Law, the electrostatic force between two point charges is directly proportional to the product of their charges and inversely proportional to the square of the distance between them.

Formula / Rule / Reaction:

$$F = k \frac{|q_1 q_2|}{r^2}$$

Solution:

- Let the initial force be $F = k \frac{q_1 q_2}{r^2}$.
- The magnitude of each charge is doubled: $q'_1 = 2q_1$ and $q'_2 = 2q_2$.
- The separation distance is halved: $r' = \frac{r}{2}$.
- Substitute these changes into Coulomb's law:

$$F' = k \frac{(2q_1)(2q_2)}{(r/2)^2} = k \frac{4q_1 q_2}{\frac{r^2}{4}} = 4 \times 4 \left(k \frac{q_1 q_2}{r^2} \right) = 16F$$

- Therefore, the force increases to 16 times its original value.

Why other options are incorrect:

- Option A:** Two times accounts for doubling only one charge without changing distance.
- Option B:** Four times accounts for doubling both charges while keeping distance unchanged, or halving distance without changing charges.
- Option C:** Eight times represents an arithmetic error in squaring the half-distance term.

Question #162 **Key: (A)**PHYSICS
02. Force & Motion

If a body having mass m_1 (2kg), moving with 5 m/s approaches another mass, m_2 (3kg) with speed $o...$

CORE CONCEPT & DERIVATION

In any perfectly elastic one-dimensional collision, the relative speed of separation after collision equals the relative speed of approach before collision.

Formula / Rule / Reaction:

$$v_{1i} - v_{2i} = -(v_{1f} - v_{2f}) \Rightarrow |v_{sep}| = |v_{app}|$$

Solution:

- The relative speed of approach before collision is given by:

$$v_{approach} = v_1 - v_2 = 5 \text{ m/s} - 1 \text{ m/s} = 4 \text{ m/s}$$

- In a perfectly elastic collision, the coefficient of restitution is $e = 1$.
- Because $e = \frac{v_{separation}}{v_{approach}} = 1$, the relative speed of separation must also be 4 m/s.

Why other options are incorrect:

- Option B:** 2 m/s violates the conservation of kinetic energy in an elastic collision.
- Option C:** 6 m/s would require non-conservative energy input during the impact.
- Option D:** Individual final velocities depend on the masses, but the relative speed of separation in a perfectly elastic collision is independent of the masses.

Question #163 **Key: (B)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Which of the following sentence has correct subject verb agreement?

CORE CONCEPT & DERIVATION

A singular subject requires a singular verb in the present tense, whereas a plural subject requires a plural verb.

Formula / Rule / Reaction:

Singular Subject (The teacher) + Singular Verb (gives)

Solution:

- The subject 'teacher' is a singular third-person noun.
- In the simple present tense, singular third-person verbs take an '-s' or '-es' suffix (gives).
- Option B correctly pairs the singular subject with the singular verb.

Why other options are incorrect:

- Option A:** Uses the plural verb form 'give' with the singular subject 'teacher'.
- Option C:** Uses the singular verb form 'gives' with the plural subject 'teachers'.
- Option D:** Uses the past participle 'given' without an auxiliary verb, creating a fragment.

Question #164 **Key: (B)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

The keys were found _____ the drawer where you left them last week.

CORE CONCEPT & DERIVATION

The preposition 'in' denotes placement or containment within an enclosed three-dimensional interior space.

Formula / Rule / Reaction:

In = Enclosed or Contained Space (e.g., in the drawer, in the box)

Solution:

- A drawer is a container designed to hold objects enclosed within its interior volume.
- The preposition 'in' correctly expresses that the keys were located inside the drawer.

Why other options are incorrect:

- Option A:** 'Under' describes a position beneath the structure of the drawer, which does not convey the normal storage of items inside it.
- Option C:** 'On' describes placement on an open exterior surface, not within a drawer.
- Option D:** 'Beside' indicates lateral proximity to the exterior of the drawer, rather than being placed within it.

Question #165 **Key: (A)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Identify the sentence among of the following, which is punctuated correctly?

CORE CONCEPT & DERIVATION

An indirect (reported) question is embedded as a declarative noun clause and does not take quotation marks, colons, or a terminal question mark.

Formula / Rule / Reaction:

Indirect Question: Reporting Verb + wh- word + Subject + Verb + Full Stop (.)

Solution:

- The sentence reports an inquiry indirectly: 'asked the principal what time the meeting would start'.
- Because it is an indirect question, normal statement word order is used (subject 'meeting' before verb 'would start') and the sentence ends with a period.
- Option A correctly avoids quotation marks, colons, and question marks.

Why other options are incorrect:

- Option B:** Incorrectly places a colon before an indirect question and places the question mark outside the closing quotation mark.
- Option C:** Lacks a closing quotation mark at the end of the direct quote.
- Option D:** Uses a semicolon incorrectly before reported speech and misplaces the question mark outside the quotation mark.

Question #166 **Key: (C)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

She was elated when she got first position in exams. What is the meaning of "elated" in this sentence...

CORE CONCEPT & DERIVATION

Contextual vocabulary relies on understanding denotative definitions and affective connotations in a given sentence.

Formula / Rule / Reaction:

'Elated' = Extremely happy, proud, joyous, or excited as a result of success

Solution:

- 'Elated' is an adjective derived from Latin *elatus*, meaning filled with high spirits and great joy.
- Achieving first position in academic examinations is an accomplishment that induces extreme joy and excitement.
- Therefore, 'excited' matches the meaning of 'elated'.

Why other options are incorrect:

- Option A:** 'Disappointed' conveys sadness resulting from unmet expectations, the opposite of elated.
- Option B:** 'Worried' describes anxiety and unease.
- Option D:** 'Mad' indicates anger or irrationality.

Question #167 **Key: (B)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

The board of directors expressed _____ disappointment with the financial results.

CORE CONCEPT & DERIVATION

A collective noun acting as a single unified entity takes a singular neuter possessive pronoun ('its') in formal standard English.

Formula / Rule / Reaction:

Collective Noun acting as a Unit (Board of directors) $\Rightarrow$ Singular Pronoun (its)

Solution:

- 'Board of directors' is a collective noun functioning as a singular unit acting in unison.
- Because the board acts collectively as one governing body, formal grammatical agreement requires the singular possessive pronoun 'its'.

Why other options are incorrect:

- Option A:** 'Their' is plural, which is avoided when collective nouns act as a single corporate body.
- Option C:** 'His or her' is used for individual persons, not an organizational board.
- Option D:** 'One's' is an indefinite personal pronoun, inappropriate for a specific collective organization.

Question #168 **Key: (C)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

It rained all night; _____ the roads were flooded in the morning.

CORE CONCEPT & DERIVATION

Conjunctive adverbs connect two independent clauses by establishing a logical relationship of cause and effect.

Formula / Rule / Reaction:

Cause (Rained all night) $\xrightarrow{\text{as a result}}$ Effect (Roads were flooded)

Solution:

- The first clause describes continuous heavy rainfall overnight (the cause).
- The second clause describes flooded roadways the following morning (the effect).
- The transitional phrase 'as a result' conveys this cause-and-effect relationship.

Why other options are incorrect:

- Option A:** 'Similarly' signals a comparison between two analogous situations.
- Option B:** 'Instead' indicates a replacement or alternative action.
- Option D:** 'In contrast' signals opposition between conflicting ideas.

Question #169 **Key: (A)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The manager accepted the cashier's _____ for coming late.

CORE CONCEPT & DERIVATION

Orthographic rules govern the derivation of nouns from Latin stems, where the verb 'explain' drops the 'i' upon adding the nominal suffix '-ation' to become 'explanation'.

Formula / Rule / Reaction:

Explain (Verb) $\rightarrow$ Explanation (Noun)

Solution:

- The correct noun form meaning a statement made to clarify or justify an action is spelled E-X-P-L-A-N-A-T-I-O-N.
- Option A is the only correctly spelled choice.

Why other options are incorrect:

- Option B:** 'Explanation' is an erroneous spelling that incorrectly retains the 'i' from 'explain'.
- Option C:** 'Explenation' incorrectly substitutes 'e' for the second 'a'.
- Option D:** 'Explanasion' incorrectly substitutes 's' for 't'.

Question #170 **Key: (C)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The writer has unearthed serious irregularities in the entire project. The word 'unearthed' in ...

CORE CONCEPT & DERIVATION

Metaphorical vocabulary relies on transferred meanings from physical actions to abstract disclosures.

Formula / Rule / Reaction:

'Unearthed' = To dig up or uncover something that was hidden or secret (exposed)

Solution:

- Literally, 'unearth' means to dig up out of the earth.
- Figuratively, in investigative and journalistic contexts, it means to discover, bring to light, or expose previously concealed facts or corrupt irregularities.
- Therefore, 'exposed' matches the meaning of 'unearthed'.

Why other options are incorrect:

- **Option A:** 'Written' refers to the act of recording text, not uncovering hidden facts.
- **Option B:** 'Mentioned' implies an incidental reference, lacking the depth of discovery conveyed by unearthing.
- **Option D:** 'Created' suggests fabricating or originating the irregularities, which alters the sentence's meaning.

Question #171 **Key: (A)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Identify the sentence with no spelling error:

CORE CONCEPT & DERIVATION

Standard English orthography requires correct lexical spelling and appropriate article usage in prepositional phrases.

Formula / Rule / Reaction:

Correct spellings: 'dinner' (d-i-n-n-e-r) and 'restaurant' (r-e-s-t-a-u-r-a-n-t)

Solution:

- 'Dinner' is correctly spelled with a double 'n'.
- 'Restaurant' is correctly spelled R-E-S-T-A-U-R-A-N-T (containing '-au-').
- Option A is the only sentence where both 'dinner' and 'restaurant' are spelled correctly.

Why other options are incorrect:

- **Option B:** 'Diner' refers to a small casual restaurant or a person eating, not an evening meal, and the article 'the' is missing before 'restaurant'.
- **Option C:** Misspells 'restaurant' as 'resturant' (missing the letter 'a').
- **Option D:** Misspells 'dinner' as 'dinnner' and 'restaurant' as 'resturant'.

Question #172 **Key: (A)**LOGICAL REASONING
07. Number Series & Numerical Progressions

What will come next? 1, 4, 2, 5, 3, 6, 4, 7, ?

CORE CONCEPT & DERIVATION

An interleaved alternating number series consists of two independent arithmetic progressions alternating in successive positions.

Formula / Rule / Reaction:

Odd terms: $a_n = 1, 2, 3, 4, \dots$ ($a_{n+1} = a_n + 1$)

Even terms: $b_n = 4, 5, 6, 7, \dots$ ($b_{n+1} = b_n + 1$)

Solution:

- Separate the given sequence into odd and even positions:
- Positions 1, 3, 5, 7, 9 (odd terms): 1, 2, 3, 4, [?]
- Positions 2, 4, 6, 8 (even terms): 4, 5, 6, 7
- The next term in the sequence occupies the 9th position (an odd term).
- Following the odd sequence (1, 2, 3, 4), the next term is $4 + 1 = 5$.

Why other options are incorrect:

- **Option B:** 6 would be the 11th term in the series.
- **Option C:** 7 is the 8th term, already present in the sequence.
- **Option D:** 8 would be the 10th term, continuing the even sequence (4, 5, 6, 7, 8).

Question #173 **Key: (A)**LOGICAL REASONING
05. Categorical Syllogisms & Overlapping Sets

All daffodils are plants. All plants are living things. Some living things are real. Conclusion...

CORE CONCEPT & DERIVATION

In deductive categorical logic, a conclusion is valid if and only if it follows necessarily from the premises without introducing unstated assumptions.

Formula / Rule / Reaction:

$$\text{Daffodils} \subset \text{Plants} \subset \text{Living Things} \implies \text{Daffodils} \subset \text{Living Things}$$

Solution:

- Premise 1 states that the set of Daffodils is entirely contained within the set of Plants.
- Premise 2 states that the set of Plants is entirely contained within the set of Living Things.
- By the transitive property of subsets, all Daffodils are necessarily Living Things; therefore, Conclusion I is valid.
- Conclusion II mentions 'flowers', a category never introduced in the premises, making it invalid.
- Premise 3 states that only *some* living things are real; we cannot deduce that daffodils are real, so Conclusion III does not follow.
- Thus, only Conclusion I logically follows.

Why other options are incorrect:

- Option B:** Incorrectly includes Conclusion II, which introduces the unstated term 'flowers'.
- Option C:** Incorrectly includes Conclusions II and III, neither of which can be logically derived from the premises.
- Option D:** Erroneously accepts all conclusions as valid.

Question #174 **Key: (C)**LOGICAL REASONING
10. Percentages, Ratios & Unit Calculations

One apple pie has 10 slices, and each apple pie feeds five people. Henry is having a party with...

CORE CONCEPT & DERIVATION

Multi-step arithmetic deduction involves determining the required number of units based on consumption rates and then calculating the total slice count.

Formula / Rule / Reaction:

$$\text{Total Slices} = \left(\frac{\text{Total People}}{\text{People per Pie}} \right) \times \text{Slices per Pie}$$

Solution:

- Each pie feeds 5 people, so feeding 200 people requires:

$$\text{Number of Pies} = \frac{200 \text{ people}}{5 \text{ people/pie}} = 40 \text{ pies}$$

- Each pie contains 10 slices, so 40 pies provide:

$$\text{Total Slices} = 40 \text{ pies} \times 10 \text{ slices/pie} = 400 \text{ slices}$$

- Therefore, Henry needs 400 slices of pie.

Why other options are incorrect:

- Option A:** 200 slices assumes each person receives only one slice, which would feed only 100 people at 2 slices per person.
- Option B:** 50 slices is fewer than needed for the 200 guests.
- Option D:** 100 slices would feed only 50 people.

Question #175 **Key: (C)**LOGICAL REASONING
10. Percentages, Ratios & Unit Calculations

How many trees are in the orchard? Which of the statements below are needed to sufficiently ans...

CORE CONCEPT & DERIVATION

Data sufficiency requires evaluating whether given statements, either alone or together, provide enough information to solve for an unknown quantity.

Formula / Rule / Reaction:

$$\text{Fraction} = \frac{1}{2}, \quad \text{Part} = 300 \implies \text{Total} = \frac{\text{Part}}{\text{Fraction}} = \frac{300}{1/2} = 600$$

Solution:

- Statement (i) gives the relative proportion (Ibrahim manages 1/2 of the trees), but provides no numerical value. Statement (i) alone is insufficient.
- Statement (ii) gives the numerical quantity under Ibrahim's care (300 trees), but does not state what proportion of the orchard this represents. Statement (ii) alone is insufficient.
- Combining both statements shows that 300 trees equals half the orchard, allowing the total to be calculated: $300 \times 2 = 600$ trees.
- Therefore, both statements together are required to answer the question.

Why other options are incorrect:

- Option A:** Statement (i) alone gives only a fraction, not the total tree count.
- Option B:** Statement (ii) alone gives only Ibrahim's share, without connecting it to the whole orchard.
- Option D:** The two statements together are sufficient to determine the total.

Question #176 Key: (B)LOGICAL REASONING
13. Blood Relations & Kinship

P, Q and R are M's parents. M and N are siblings. Q is N's mother. What is P to M?

CORE CONCEPT & DERIVATION

Kinship logical deduction tracks familial relationships through shared parentage and gender roles.

Formula / Rule / Reaction:

Siblings share the same biological parents: Father and Mother

Solution:

- M and N are siblings, meaning they share the same parents.
- Q is identified as N's mother, which means Q is also M's mother.
- Because P is identified as a parent of M alongside mother Q, P must be the father.

Why other options are incorrect:

- **Option A:** Q is already established as the mother.
- **Option C:** P is a parent, not a sibling (sister).
- **Option D:** P is a parent, not a brother.

Question #177 Key: (A)LOGICAL REASONING
10. Percentages, Ratios & Unit Calculations

Asad bought 50 packets of biscuits for the price of Rs. 500; whereas Anum bought 25 packets of ...

CORE CONCEPT & DERIVATION

Unit pricing determines the cost of a single item, allowing direct mathematical comparison between two quantities.

Formula / Rule / Reaction:

$$\text{Unit Price} = \frac{\text{Total Cost}}{\text{Quantity}}$$

Solution:

- Calculate the unit price for a packet of biscuits:

$$\text{Price per biscuit packet} = \frac{\text{Rs. 500}}{50} = \text{Rs. 10}$$

- Calculate the unit price for a packet of chips:

$$\text{Price per chip packet} = \frac{\text{Rs. 1000}}{25} = \text{Rs. 40}$$

- Compare the prices:

$$\text{Cost of 4 biscuit packets} = 4 \times \text{Rs. 10} = \text{Rs. 40} = \text{Cost of 1 chip packet}$$

- Therefore, the price of 4 packets of biscuits equals the price of 1 packet of chips.

Why other options are incorrect:

- **Option B:** Inverts the relationship by claiming one biscuit packet costs as much as four chip packets (Rs. 160).
- **Option C:** Two biscuit packets cost Rs. 20, which is only half the price of one chip packet (Rs. 40).
- **Option D:** Claims one biscuit packet (Rs. 10) equals two chip packets (Rs. 80).

Question #178 Key: (B)LOGICAL REASONING
07. Number Series & Numerical Progressions

The virus spreads rapidly in the town. It infected the people – First day: 8, Second day: 16, T...

CORE CONCEPT & DERIVATION

Geometric progressions exhibit a constant common ratio (r) between consecutive terms.

Formula / Rule / Reaction:

$$a_n = a_1 \cdot r^{n-1} \implies r = \frac{16}{8} = \frac{32}{16} = 2$$

Solution:

- Day 1 count = 8
- Day 2 count = $8 \times 2 = 16$
- Day 3 count = $16 \times 2 = 32$
- Each day the number of newly infected individuals doubles.
- On Day 4, the expected count is $32 \times 2 = 64$ people.

Why other options are incorrect:

- **Option A:** 44 assumes an arbitrary increase of 12.
- **Option C:** 96 assumes a tripling from Day 3 (32×3), which does not fit the doubling trend.
- **Option D:** 54 does not follow the geometric ratio of 2.

Question #179 Key: (D)LOGICAL REASONING
03. Courses of Action & Decision-Making

Which of the following is a result of poor design that could cause an accident in the workplace...

CORE CONCEPT & DERIVATION

Occupational health and safety ergonomics distinguishes structural engineering design defects from routine operational maintenance or housekeeping issues.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- An unplanned workspace layout is an inherent flaw in architectural design and workflow planning.
- Poor layout causes congestion, obstructs emergency egress pathways, and forces dangerous proximity between workers and machinery.
- Therefore, an unplanned workspace layout is a direct consequence of poor design planning.

Why other options are incorrect:

- **Option A:** Equipment failure typically results from mechanical wear or insufficient maintenance over time, rather than layout design.
- **Option B:** Slippery surfaces are transient housekeeping or surface-cleaning issues.
- **Option C:** Insufficient lighting is an environmental utility or maintenance deficiency.

Question #180 **Key: (B)**LOGICAL REASONING
03. Courses of Action & Decision-Making

Which of the following is the main cause of accidents involving equipment?

CORE CONCEPT & DERIVATION

Industrial equipment safety analyses show that mechanical failures, component degradation, and structural malfunctions stem primarily from inadequate maintenance schedules.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Machinery components undergo wear, vibration fatigue, and lubrication breakdown during regular use.
- Insufficient preventive maintenance leads directly to mechanical failure, component jamming, brake failure, and subsequent workplace accidents.
- Therefore, insufficient maintenance is recognized as the leading equipment-related cause of accidents.

Why other options are incorrect:

- **Option A:** Overconfidence is a behavioral human factor that affects risk-taking, but is not the primary cause of equipment failure.
- **Option C:** Fatigue impairs operator reaction time, but does not cause mechanical equipment breakdown.
- **Option D:** Poor training contributes to operator error, but the condition of the machinery itself depends directly on regular maintenance.