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UHS LAHORE

UHS Lahore MDCAT 2024 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-2024 ⌚ Duration: 200 Minutes (3h 20m)

200 TOTAL QUESTIONS	200m OFFICIAL DURATION	+1 / 0.00 ZERO NEGATIVE MARKING	200 MAXIMUM MARKS
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📄 EXAMINATION BLUEPRINT & SUBJECT WEIGHTAGE

Biology 68 MCQs 34.0% weight	Chemistry 54 MCQs 27.0% weight	Physics 54 MCQs 27.0% weight	English 18 MCQs 9.0% weight	Logical Reasoning 6 MCQs 3.0% weight
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BIO SECTION: BIOLOGY

Questions 1 to 68 (68 MCQs)

Q1. BIO

Which of the following neurotransmitters is lying outside the central nervous system?

- (A) Acetylcholine
- (B) Endorphins
- (C) Gamma-aminobutyric acid
- (D) Dopamine

Q2. BIO

Depolarization during conduction of nerve impulse is due to:

- (A) Inward movement of Na^+
- (B) Inward movement of K^+
- (C) Outward movement of K^+
- (D) Outward movement of Na^+

Q3. BIO

Which of the following is NOT a feature of the autonomic nervous system?

- (A) Regulate response of visceral organs
- (B) Regulate response of skeletal muscles
- (C) Regulate response of glands
- (D) Regulate response of smooth muscles

Q4. BIO

Taste receptor is an example of:

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

Q5. BIO

Mesosomes are the invaginations of which bacterial cell structure?

- (A) Cell wall
- (B) Cell membrane
- (C) Plasmid
- (D) Cysts

Q6. BIO

Which of the following belongs to chordates?

- (A) Spider
- (B) Earthworm
- (C) Trout fish
- (D) Star fish

Q7. BIO

Which of the following statements is incorrect regarding the rate of enzymatic reaction?

- (A) Increase in enzyme concentration increases the rate
- (B) Increase in enzyme concentration reduces the rate
- (C) All enzymes work at their maximum rate at their optimum temperature
- (D) All enzymes work at maximum rate at optimum pH

Q8. BIO

Induced fit model of enzyme activity suggests that enzyme:

- (A) Cannot modify its active sites
- (B) Can bind to a single substrate
- (C) Can catalyze related reactions
- (D) Usually belongs to non-regulatory enzyme

Q9. BIO

Female reproductive system consists of all of the following EXCEPT:

- (A) Ovaries
- (B) Oviduct
- (C) Cervix
- (D) Seminiferous tubules

Q10. BIO

Chromosomal abnormality in Turner syndrome is represented by:

- (A) XXX
- (B) XYY
- (C) XO
- (D) XXY

Q11. BIO

Which one of the following hormones is responsible for the labor pains in a human female at the time of the birth of a baby?

- (A) Estrogen
- (B) Progesterone
- (C) Oxytocin
- (D) Corticosteroid

Q12. BIO

The change in frequency of alleles at a locus that occurs by chance is known as:

- (A) Mutation
- (B) Genetic Drift
- (C) Non-Random mating
- (D) Speciation

Q13. BIO

Fluid secreted by Sertoli cells provides a liquid medium, protection, and nourishment to:

- (A) Oocyte
- (B) Sperms
- (C) Polar body
- (D) Spermatogonia

Q14. BIO

Identify the correct pair of vestigial organs:

- (A) Ear Muscles & Vermiform appendix
- (B) Heart and Liver
- (C) Ear Muscles & Liver
- (D) Vermiform appendix & Heart

Q15. BIO

Which of the following increases variation within a gene pool?

- (A) Chromosome inversion
- (B) Crossing over
- (C) Gene mutation
- (D) Random fusion of gametes

Q16. BIO

Corpus luteum during female reproductive cycle produces:

- (A) Testosterone
- (B) Follicle stimulating hormone
- (C) Luteinizing hormone
- (D) Progesterone

Q17. BIO

Which of the following statements about natural selection is not true?

- (A) It affects variations that are heritable
- (B) It is selected by a breeder
- (C) It can improve the adaptation of species
- (D) It is regional in nature

Q18. BIO

The formula calculating the frequency of genotypes and alleles in a population gene pool is known as:

- (A) Hardy-Weinberg Equation
- (B) Lamarck Equation
- (C) Darwin Equation
- (D) James Hutton Equation

Q19. BIO

Due to the process of follicle atresia:

- (A) Follicles reach maximum size
- (B) Follicle degenerates
- (C) Graafian follicle ovulates
- (D) The follicle starts to mature

Q20. BIO

The idea of inheritance of acquired characteristics was presented by:

- (A) Jean Baptist Lamarck
- (B) Charles Darwin
- (C) Thomas Malthus
- (D) Alfred Wallace

Q21. BIO

Main function of the epididymis is to:

- (A) Transport sperms
- (B) Connect with urethra
- (C) Produce semen
- (D) Hold the process of spermatogenesis

Q22. BIO

According to endosymbiosis theory, flagella may have been derived by the ingestion of prokaryotes similar to:

- (A) Amoeboid prokaryote
- (B) Aerobic bacterium
- (C) Spirochete
- (D) Spirillum

Q23. BIO

Immediate next stage of spermatogonia differentiation is:

- (A) Secondary spermatocyte
- (B) Spermatids
- (C) Primary spermatocytes
- (D) Sperms

Q24. BIO

Insulin converts glucose into:

- (A) Vitamins
- (B) Minerals
- (C) Lipids
- (D) Cortisone

Q25. BIO

Which of the following is included in paired cranial bones?

- (A) Temporal
- (B) Occipital
- (C) Frontal
- (D) Vomer

Q26. BIO

About 70% of the carbon dioxide is carried in blood as:

- (A) Carbonate
- (B) Bicarbonate
- (C) Tricarbonate
- (D) Carbonic anhydrase

Q27. BIO

Which of the following skeletal disorders is an example of an autoimmune disorder?

- (A) Sciatica
- (B) Spondylosis
- (C) Rheumatoid arthritis
- (D) Rickets

Q28. BIO

Range of normal total lung capacity in humans is:

- (A) 5–6 liter
- (B) 8–9 liter
- (C) 10–11 liter
- (D) 12–13 liter

Q29. BIO

Which feature is possessed by smooth muscles?

- (A) Voluntary
- (B) Branched
- (C) Uninucleate
- (D) Striated appearance

Q30. BIO

Respiration in *Pseudomonas* bacteria is:

- (A) Aerobic
- (B) Anaerobic
- (C) Facultative
- (D) Microaerophil

Q31. BIO

The accumulation of 'lactic acid' in the muscles results in:

- (A) Extreme fatigue
- (B) Muscle contraction
- (C) Paralysis
- (D) Convulsion

Q32. BIO

The autotrophic mode of nutrition in an organism depends upon the following:

- (A) Saprotrophic mode
- (B) Parasitic mode
- (C) Photosynthesis mode
- (D) Obligate mode

Q33. BIO

Thick filaments in skeletal muscles are composed of:

- (A) Actin
- (B) Myosin
- (C) Tropomyosin
- (D) Troponin

Q34. BIO

Prokaryotic cells lack:

- (A) Mesosomes
- (B) Ribosomes
- (C) Storage bodies
- (D) Membrane bound organelles

Q35. BIO

Bacterial genome becomes diploid:

- (A) After fertilization of gametes
- (B) Before spore formation
- (C) During binary fission
- (D) After binary fission

Q36. BIO

In the journey of electrons from photosystem II to photosystem I plastocyanin is reduced by:

- (A) Plastoquinone
- (B) Cytochrome complex
- (C) P700
- (D) Primary electron acceptor of PSI

Q37. BIO

Enzyme NADP reductase is responsible for:

- (A) Reducing NADP⁺
- (B) Oxidizing NADP⁺
- (C) Reducing Ferredoxin
- (D) Reducing P700

Q38. BIO

The PS II, during light reactions, receives electrons from splitting:

- (A) Water
- (B) Plastoquinone
- (C) Plastocyanin
- (D) Ferredoxin

Q39. BIO

Mono-saccharides have a general formula represented by:

- (A) $(CH_2O)_n$
- (B) $C(H_2O)_n$
- (C) $C_2(H_2O)_n$
- (D) $C_x(H_2O)_y$

Q40. BIO

What is the percentage of H₂O in bone cells?

- (A) 70%
- (B) 20%
- (C) 99%
- (D) 60%

Q41. BIO

When glycerol reacts with fatty acid, which type of chemical bond will form?

- (A) Ester bond
- (B) Ether linkage
- (C) Hydrogen bond
- (D) Ionic bond

Q42. BIO

Polysaccharides in plants are synthesized by the process of:

- (A) Hydrolysis
- (B) Oxidation
- (C) Condensation
- (D) Glycolysis

Q43. BIO

Which of the following process is involved in breakdown of protein into Amino acids?

- (A) Condensation
- (B) Hydrolysis
- (C) Glycolysis
- (D) Fixation

Q44. BIO

Sarcomere is part of myofibril between:

- (A) Two I bands
- (B) Two A bands
- (C) Two M lines
- (D) Two Z lines

Q45. BIO

Chloroplast are membrane bound bodies containing:

- (A) Enzymes
- (B) Cisternae
- (C) Pigment
- (D) Cristae

Q46. BIO

Which of the following is the function of Golgi Complex?

- (A) Intracellular digestion
- (B) Autophagy
- (C) Autolysis
- (D) Processing of cell secretions

Q47. BIO

The hydrophilic end of the phospholipid molecule is polar because of the presence of:

- (A) Glycerol
- (B) Amine group
- (C) Fatty Acid
- (D) Phosphate group

Q48. BIO

Nissl's granules are groups of:

- (A) Mesosomes
- (B) Lysosomes
- (C) Ribosomes
- (D) Chromosome

Q49. BIO

Which monosaccharide will form a gluco-pyranose ring in solution?

- (A) Fructose
- (B) Glucose
- (C) Ribose
- (D) Deoxyribose

Q50. BIO

The nucleus takes dyes due to the presence of:

- (A) Chromatin
- (B) Lipid
- (C) Metal ions
- (D) Thylakoids

Q51. BIO

The organelles only found at seeding stage in oil seed plants are:

- (A) Peroxisomes
- (B) Glyoxysomes
- (C) Microbodies
- (D) Vacuoles

Q52. BIO

Posterior lobe of pituitary produce:

- (A) Antidiuretic Hormone (ADH)
- (B) Thyroid Stimulating Hormone (TSH)
- (C) Adrenocorticotrophic Hormone (ACTH)
- (D) Follicle Stimulating Hormone (FSH)

Q53. BIO

In human myelinated fibres nerve impulse travels at _____ meters per second.

- (A) 100–120
- (B) 130–150
- (C) 160–180
- (D) 190–210

Q54. BIO

One of the following is CORRECT regarding flagella:

- (A) Made up of microfilaments
- (B) Contains centriole
- (C) Originates from basal bodies
- (D) They are immobile

Q55. BIO

During the non-conducting state, the neuron membrane is permeable to the efflux of:

- (A) K^+
- (B) Na^+
- (C) Ca^{2+}
- (D) Cl^-

Q56. BIO

Medulla Oblongata is a part of:

- (A) Forebrain
- (B) Mid brain
- (C) Hind brain
- (D) Hippocampus

Q57. BIO

Which option is CORRECT about endospore?

- (A) Has a short dormant period
- (B) Contains moisture for survival
- (C) Metabolically active
- (D) Endures extreme conditions

Q58. BIO

Which of the following is NOT a bone of upper limb?

- (A) Humerus
- (B) Ulna
- (C) Femur
- (D) Radius

Q59. BIO

Bacteria divide at an exponential rate during the growth phase:

- (A) Lag
- (B) Log
- (C) Stationary
- (D) Decline

Q60. BIO

Bone forming cells are:

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

Q61. BIO

Example of viruses having a polyhedral capsid that is with 252 capsomeres is:

- (A) Adenovirus
- (B) Tobacco Mosaic Virus
- (C) Influenza virus
- (D) Bacteriophage

Q62. BIO

The chromosomes were first observed by:

- (A) T. H Morgan
- (B) Griffith
- (C) Walther
- (D) Mendel

Q63. BIO

The complete, mature & infectious particle of virus is known as:

- (A) Genome
- (B) Capsomere
- (C) Virion
- (D) Envelope

Q64. BIO

The causative organism of measles is:

- (A) Poxivirus
- (B) Paparivirus
- (C) Picornovirus
- (D) Paramyxovirus

Q65. BIO

In the life cycle of a bacteriophage, the lysozymes are required in which of the following steps of the infection process?

- (A) Genome injection
- (B) Penetration
- (C) Replication
- (D) Adsorption

Q66. BIO

_____ is transmitted through infected blood and hypodermic syringes.

- (A) HIV
- (B) Influenza virus
- (C) Morbilli virus (Measles)
- (D) Vibrio Cholerae (Cholera)

Q67. BIO

In the Calvin cycle, CO_2 reacts with RuBP to produce _____.

- (A) 3-PGA
- (B) G3P
- (C) 6-Carbon unstable intermediate
- (D) 1,3 bisphosphoglycerate

Q68. BIO

Which option is correct about a chlorophyll molecule?

- (A) Chemical formula $\text{C}_{55}\text{H}_{70}\text{O}_6\text{N}_4\text{Mg}$
- (B) Porphyrin ring with nitrogen in centre
- (C) Methyl group on second pyrrole ring
- (D) Aldehyde group on second pyrrole ring

CHEM SECTION: CHEMISTRY

Questions 69 to 122 (54 MCQs)

Q69. CHEM

Which of the following alcohol can give a Iodoform reaction?

- (A) Methanol
(B) 1-Butanol
(C) 1-Propanol
(D) Ethanol

Q70. CHEM

Which of the following is the correct Arrhenius equation?

- (A) $k = Ae^{-E_a/QT}$
(B) $k = Ae^{-E_a/RT}$
(C) $k = Ae^{-E_a/ST}$
(D) $k = Ae^{-E_a/UT}$

Q71. CHEM

Which of the following electronic configurations is correct for carbon?

- (A) $1s^2, 2s^2, 2p^3$
(B) $1s^2, 2s^2, 2p^4$
(C) $1s^2, 2s^2, 2p^2$
(D) $1s^2, 2s^2, 2p^1$

Q72. CHEM

Common name of 2-hydroxy propanoic acid is:

- (A) Tartaric acid
(B) Lactic acid
(C) Phthalic acid
(D) Formic acid

Q73. CHEM

In endothermic reaction, the heat content of the:

- (A) Reactants and products is equal
(B) Reactants is more than that of products
(C) Products is more than that of reactants
(D) Reactants & Products will not change

Q74. CHEM

Intermolecular forces between molecules of ideal gas are:

- (A) Strong
(B) Moderate
(C) Weak
(D) Absent

Q75. CHEM

Which of the following is correct regarding phenol?

- (A) Phenol and water are equally acidic
(B) Phenol is less acidic than carboxylic acid
(C) Phenol is less acidic than water
(D) Phenol is less acidic than ethanol

Q76. CHEM

The correct ideal gas equation is:

- (A) $qV = nRT$
(B) $pV = nRT$
(C) $gV = nRT$
(D) $yV = nRT$

Q77. CHEM

The real gases show deviation from ideal behaviour at:

- (A) Low temperature and low pressure
(B) High temperature and high pressure
(C) Low temperature and high pressure
(D) High temperature and low pressure

Q78. CHEM

To boil water at 110 °C, external pressure should be:

- (A) 200–760 torr
(B) 760–1200 torr
(C) 665–670 torr
(D) 660–700 torr

Q79. CHEM

Which of the following is not basic in nature?

- (A) Aluminum oxide
(B) Magnesium oxide
(C) Potassium oxide
(D) Sodium oxide

Q80. CHEM

The solubility of sulphates of alkaline earth metals generally:

- (A) Increase down the group
(B) Decrease down the group
(C) Increase then decrease down the group
(D) Doesn't change down the group

Q81. CHEM

The atomic masses of elements depend upon:

- (A) Atomic number
(B) Number of electrons
(C) Number of isotopes & their abundance
(D) None of the above

Q82. CHEM

Which one of the following DO NOT have a tendency to form hydrogen bonding?

- (A) Ammonia
(B) Ethyl alcohol
(C) Carboxylic acids
(D) Hydrocarbon

Q83. CHEM

Which of the following is an example of substituent group which release electrons to benzene ring?

- (A) $-\text{CN}$
(B) $-\text{NR}_3^+$
(C) $-\text{NH}_2$
(D) $-\text{NO}_2$

Q84. CHEM

Which type of isomerism is displayed by compounds having the same structural formula but different positions of atoms on both sides of the carbon bond?

- (A) Chain
(B) Metamerism
(C) Geometric
(D) Tautomerism

Q85. CHEM

Which of the following is NOT an Alloy?

- (A) Steel
- (B) Brass
- (C) Bronze
- (D) Graphite

Q86. CHEM

Electronic configuration of chromium (proton number 24) is:

- (A) $[\text{Ar}] 3d^4 4s^2$
- (B) $[\text{Ar}] 3d^2 4s^2$
- (C) $[\text{Ar}] 3d^5 4s^1$
- (D) $[\text{Ar}] 3d^5 4s^2$

Q87. CHEM

Which step is irrelevant concerning the balancing of redox equations by the oxidation number method?

- (A) Split the reaction into two half reactions.
- (B) Assign an oxidation number to all the atoms involved in the equation.
- (C) Identify the element changing oxidation number
- (D) Equalize the number of electrons lost and gained

Q88. CHEM

Which of the following is NOT a correct feature of electrolytic cells?

- (A) Reduction occurs at cathode
- (B) Oxidation occurs at anode
- (C) Alternating current source is connected to electrodes
- (D) Electrochemical reaction takes place

Q89. CHEM

Which of the following has a coordinate bond?

- (A) NaCl
- (B) CaO
- (C) NH_3BF_3
- (D) H_2O

Q90. CHEM

Which of the following is NOT a feature of Valence Shell Electron Pair Repulsion theory?

- (A) It determines the shape of molecule
- (B) Pairs of electrons repel each other.
- (C) It helps in understanding the interaction of medicinal drug molecules.
- (D) Only lone pairs participate in determining geometry of molecules.

Q91. CHEM

Which of the following has smallest atomic radius:

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

Q92. CHEM

The difference of lithium from the other alkali metals is mainly because of:

- (A) Large radius and low charge density
- (B) Small radius and low charge density
- (C) Large radius and high charge density
- (D) Small radius and high charge density

Q93. CHEM

Boiling point of a liquid is a temperature at which:

- (A) Surface tension is greater than the atmospheric pressure
- (B) Viscosity is less than the atmospheric pressure
- (C) Vapor pressure equals the atmospheric pressure
- (D) Viscosity equals the atmospheric pressure

Q94. CHEM

Which of the following is NOT a property of transition elements?

- (A) High melting points
- (B) Good conductors of electricity
- (C) Hard metals
- (D) Ions and compounds are colorless

Q95. CHEM

1-Butene and two Butene are showing which type of isomerism?

- (A) Functional group
- (B) Positional
- (C) Metamerism
- (D) Chain

Q96. CHEM

Whenever the crystalline solids are broken they do so along definite planes known as:

- (A) Cleavage planes
- (B) Refractory planes
- (C) Sagittal planes
- (D) Coronal planes

Q97. CHEM

Homocyclic organic compounds are subdivided into two types, namely:

- (A) Alicyclic and Aromatic
- (B) Alkenes and alkynes
- (C) Aromatic and Non-aromatic
- (D) Saturated and unsaturated

Q98. CHEM

One of the following is NOT an example of amorphous solids?

- (A) Plastic
- (B) Glass
- (C) Glucose
- (D) Rubber

Q99. CHEM

In graphite the carbon atoms are arranged in which of the following structure?

- (A) Rhombic
- (B) Hexagonal
- (C) Tetragonal
- (D) Trigonal

Q100. CHEM

The principle that states that if a stress is applied to a system at equilibrium, the system nullifies the effect of stress as far as possible is:

- (A) Haber's
- (B) Le-Chatelier
- (C) Boyle's
- (D) Charles'

Q101. CHEM

In Friedel Craft acylation an acyl group is introduced in benzene ring in the presence of catalyst:

- (A) AlCl_3
- (B) H_2SO_4
- (C) Sunlight
- (D) V_2O_5

Q102. CHEM

Identify the CORRECT option required for the maximum yield of ammonia by Haber's Process:

- (A) High pressure, low temperature, continual removal of ammonia
- (B) Low pressure, low temperature, continual removal of ammonia
- (C) High pressure, high temperature, continual removal of ammonia
- (D) High pressure, low temperature, continual addition of ammonia

Q103. CHEM

Which one of the following represents nitration of benzene correctly?

- (A) $\text{C}_6\text{H}_6 + \text{HNO}_3 \xrightarrow{\text{conc. HCl}} \text{C}_6\text{H}_5\text{NO}_2 + \text{H}_2\text{O}$
- (B) $\text{C}_6\text{H}_6 + \text{HNO}_3 \xrightarrow{\text{conc. H}_2\text{SO}_4, 50-55^\circ\text{C}} \text{C}_6\text{H}_5\text{NO}_2 + \text{H}_2\text{O}$
- (C) $\text{C}_6\text{H}_6 + \text{HNO}_2 \xrightarrow{\text{conc. H}_2\text{SO}_4} \text{C}_6\text{H}_5\text{NO}_2 + \text{H}_2\text{O}$
- (D) $\text{C}_6\text{H}_6 + \text{HNO}_3 \xrightarrow{\text{AlCl}_3} \text{C}_6\text{H}_5\text{NO}_2 + \text{H}_2\text{O}$

Q104. CHEM

The number of moles in an element is directly proportional to:

- (A) Mass of an element
- (B) Empirical formula mass
- (C) Molar mass of an element
- (D) Formula mass

Q105. CHEM

Identify the correct ascending order of reactivity of alkyl halides:

- (A) $\text{Cl}, \text{Br}, \text{I}, \text{F}$
- (B) $\text{F}, \text{Cl}, \text{Br}, \text{I}$
- (C) $\text{Br}, \text{I}, \text{F}, \text{Cl}$
- (D) $\text{I}, \text{F}, \text{Cl}, \text{Br}$

Q106. CHEM

Consider the following reaction in equilibrium and tell which chemical addition will turn the cloudy solution into a clear solution?



- (A) BiCl_3
- (B) H_2O
- (C) BiOCl
- (D) HCl

Q107. CHEM

The type and relative amount of each isotope in an element can be found by:

- (A) IR spectroscopy
- (B) UV spectroscopy
- (C) Mass Spectrometry
- (D) NMR

Q108. CHEM

Identify the correct statement related to substitution and elimination of alkyl halides:

- (A) Strong bases cause substitution in preference to elimination
- (B) Role of leaving groups in elimination is similar to substitution
- (C) Substitution is favored more than elimination by decreasing solvent polarity
- (D) Decrease in temperature will favor elimination more than substitution

Q109. CHEM

Identify the correct formula to calculate the rate of reaction.

- (A) $\frac{\text{Change in concentration of substance}}{\text{Time taken for the change}}$
- (B) Time taken for the change + Change in concentration of substance
- (C) (Time taken for the change + Change in concentration of substance) $\times 100$
- (D) Time taken for the change $\times$ Change in concentration of substance

Q110. CHEM

Alkyl Halides involving C-X bond breakage and C-Nu bond formation simultaneously:

- (A) $\text{S}_\text{N}1$
- (B) $\text{S}_\text{N}2$
- (C) $\text{E}1$
- (D) $\text{E}2$

Q111. CHEM

$\text{C}_n\text{H}_{2n}\text{O}$ is the general formula of:

- (A) Ether
- (B) Carboxylic acid
- (C) Ketones
- (D) Carboic acid

Q112. CHEM

Consider the hypothetical equation $a\text{A} + b\text{B} \rightarrow c\text{C} + d\text{D}$: Which of the following represents the correct rate equation?

- (A) $\text{Rate} = k[\text{A}][\text{B}]$
- (B) $\text{Rate} = k[\text{A}]^a[\text{B}]^b$
- (C) $\text{Rate} = k[\text{A}]^a$
- (D) $\text{Rate} = k[\text{B}]^b$

Q113. CHEM

The blue color of Fehling solution is changed to red when warmed with an aldehyde due to the formation of which of the following?

- (A) CO_2
- (B) Cu_2O
- (C) Ag_2O
- (D) SO_2

Q114. CHEM

If a reaction rate does not change with concentration, then it is:

- (A) 3rd order
- (B) 2nd order
- (C) 1st order
- (D) Zero order

Q115. CHEM

The reaction of formaldehyde with HCN is:

- (A) Nucleophilic substitution
- (B) Nucleophilic addition
- (C) Electrophilic substitution
- (D) Free radical addition

Q116. CHEM

No individual atom in the sample of 1 mole of Neon has a mass of 20.18 a.m.u. Because it is:

- (A) Overall mass of an isobar
- (B) It is a fractional mass
- (C) It is molar mass of Ne
- (D) The average atomic mass of Ne

Q117. CHEM

The p orbital has:

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

Q118. CHEM

All of the following steps are used to calculate the lattice energy in the Born-Haber cycle EXCEPT:

- (A) Atomizing the metal
- (B) Ionizing the metal
- (C) Deionize the metal
- (D) Ionize non metal

Q119. CHEM

The enthalpy change when 1 Mole of water is formed by the reaction of acid with an alkali under standard conditions is known as:

- (A) Enthalpy of formation
- (B) Enthalpy of reaction
- (C) Enthalpy of combustion
- (D) Enthalpy of neutralization

Q120. CHEM

When carboxylic acid is heated with alcohol in the presence of sulphuric acid, one of the following is formed.

- (A) Amides
- (B) Acyl chloride
- (C) Esters
- (D) Acid anhydride

Q121. CHEM

The oxidation number of 'Mn' in KMnO_4 is:

- (A) 0
- (B) +1
- (C) -7
- (D) +7

Q122. CHEM

Which one of the following is not an amino acid?

- (A) Folic acid
- (B) Glutamic acid
- (C) Glycine
- (D) Lysine

PHY SECTION: PHYSICS

Questions 123 to 176 (54 MCQs)

Q123. PHY

In an elastic collision, the total kinetic energy:

- (A) Dissipates after collision
- (B) Increases after the collision
- (C) Reduces after the collision
- (D) Before and after collision remains the same

Q124. PHY

The instantaneous velocity along the curved path is:

- (A) Along the tangent
- (B) Perpendicular to the slope
- (C) Parallel to the radius
- (D) Anti-parallel to the radius

Q125. PHY

The range of projectile will be maximum if the factor $\sin 2\theta$ becomes:

- (A) Zero
- (B) 1
- (C) -1
- (D) 2

Q126. PHY

The two-dimensional motion under constant acceleration due to gravity is called:

- (A) Circular motion
- (B) Rotational motion
- (C) Projectile motion
- (D) Vibratory motion

Q127. PHY

In a velocity-time graph, the area under the graph is equal to the:

- (A) Speed of an object
- (B) Velocity of an object
- (C) Distance covered by object
- (D) Acceleration of an object

Q128. PHY

According to Newton's Law of Motion, the mass of the object is a quantitative measure of its:

- (A) Weight
- (B) Inertia
- (C) Speed
- (D) Acceleration

Q129. PHY

$1 \text{ kWh} = \text{_____ J?}$

- (A) 3.6 J
- (B) 3.6 kJ
- (C) 3.6 MJ
- (D) 3.6 GJ

Q130. PHY

Which of the following is a non-conservative force?

- (A) Frictional force
- (B) Electric force
- (C) Elastic spring force
- (D) Gravitational force

Q131. PHY

Work-done is equal to:

- (A) Effort $\times$ distance
- (B) Effort + distance
- (C) Effort - distance
- (D) Effort / distance

Q132. PHY

When a force of 1 N displaces its point of application by 1 m in the direction of the force, the work done is:

- (A) 1 J
- (B) 10 J
- (C) 0 J
- (D) 100 J

Q133. PHY

An electric motor is used to lift the weight of 2.0 N through a vertical distance of 100 cm in 4 sec. What is the power output of the motor?

- (A) 25 W
- (B) 0.5 W
- (C) 0.75 W
- (D) 1 W

Q134. PHY

The centripetal acceleration of an object moving along a circle of radius 'r' with an angular speed ' ω ' is given by the formula:

- (A) $a = r\omega^2$
- (B) $a = r\omega$
- (C) $a = r^2\omega$
- (D) $a = r^2\omega^2$

Q135. PHY

An air craft makes a turn in a horizontal circle of radius 100 m. It is travelling with a velocity of 250 m/sec. The angular velocity of the air craft will be:

- (A) 1.5 rad/sec
- (B) 2.5 rad/sec
- (C) 3 rad/sec
- (D) 3.5 rad/sec

Q136. PHY

A particle of mass 'm' is moving on a circular path of radius 'r' with velocity 'v', then centripetal force acting on it is F. If the velocity of particle increases by 2 times and radius of circular path increases by 4 times then new centripetal force F' will be:

- (A) $F' = 2F$
- (B) $F' = \frac{1}{2}F$
- (C) $F' = 4F$
- (D) $F' = F$

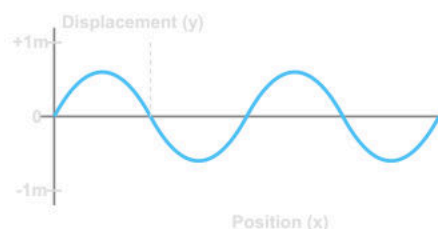
Q137. PHY

A roller coaster is moving with $30 \text{ m} \cdot \text{s}^{-1}$ on a circular track of radius 30 m. The net mass of coaster + passengers is 'm'. The centripetal force acting on it is:

- (A) 900m
- (B) 10m
- (C) 450m
- (D) 30m

Q138. PHY

Amplitude in the following figure is given as:



- (A) 2 m
- (B) 0.5 m
- (C) 4 m
- (D) 1 m

Q139. PHY

Which one of the following is INCORRECT about the nodes when the string is plucked?

- (A) Amplitude of vibration is zero.
- (B) Do not move along the string.
- (C) Produced at the fixed ends of strings
- (D) The distance between consecutive nodes is 1 wavelength.

Q140. PHY

In transverse waves the portion above the mean level is called:

- (A) Wave front
- (B) Wave crest
- (C) Wave trough
- (D) Wavelength

Q141. PHY

Which one of the following does not cause stationary waves?

- (A) Two waves of equal frequency
- (B) Two waves of the same speed
- (C) Two waves of unequal amplitude
- (D) Two waves travelling in opposite directions

Q142. PHY

Select the appropriate Doppler equation when source is approaching the stationary observer where f_o is the observed frequency, f_s is frequency of source, v is the speed of sound, v_s is the speed of source relative to observer:

- (A) $f_o = f_s \frac{v+v_s}{v}$
- (B) $f_o = f_s \frac{v}{v+v_s}$
- (C) $f_o = f_s \frac{v}{v-v_s}$
- (D) $f_o = f_s \frac{v+v_s}{v-v_s}$

Q143. PHY

The distance between two successive particles which are exactly in the same state of vibration is called:

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

Q144. PHY

During the isothermal process, the temperature:

- (A) Remains constant during the initial phase of the process
- (B) Remains constant throughout the process
- (C) Alters throughout the process
- (D) Increases throughout the process

Q145. PHY

What is the value of heat energy (Q) in an adiabatic process?

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

Q146. PHY

The Coulomb's law states:

- (A) Force between two point charges is inversely proportional to the product of the charges and directly proportional to the square of the distance between them.
- (B) Force between two point charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between them.
- (C) Force between two point charges is directly proportional to the sum of the charges and inversely proportional to the square of the distance between them.
- (D) Force between two point charges is directly proportional to the product of the charges and to the square of the distance between them.

Q147. PHY

The formula $V = \frac{W}{q_0}$ represents:

- (A) Electric intensity
- (B) Electric power
- (C) Electric potential
- (D) Electric field gradient

Q148. PHY

The S.I unit of capacitance of a capacitor is:

- (A) Coulomb
- (B) Volt
- (C) Farad
- (D) Ampere

Q149. PHY

Electric intensity between two oppositely charge plates in the middle region is:

- (A) Non-uniform
- (B) Uniform
- (C) Cannot be predicted
- (D) Variable

Q150. PHY

Find the potential difference in moving a 2 C charge, which requires 600 J of work between two points.

- (A) 1200 V
- (B) 300 V
- (C) 150 V
- (D) 2400 V

Q151. PHY

Which one of the following is NOT a feature of electric forces?

- (A) They act on charges
- (B) They act on masses
- (C) They can be attractive
- (D) They can be repulsive

Q152. PHY

A charge of 90 C passes through a wire for 30 seconds. Then the current in the wire will be:

- (A) 3 A
- (B) 0.3 A
- (C) 3 mA
- (D) 0.3 mA

Q153. PHY

The magnitude of the current in metals is proportional to the potential difference across it as long as the temperature of the conductor is kept constant is known as:

- (A) Joule's Law
- (B) Gauss Law
- (C) Ohm's Law
- (D) Ampere's Law

Q154. PHY

When length of copper wire is doubled then resistivity becomes:

- (A) Double
- (B) Half
- (C) Remains same
- (D) Four times

Q155. PHY

The resistance of semi-conductor with rise in temperature:

- (A) Increases
- (B) Decreases
- (C) Remain same
- (D) Infinite

Q156. PHY

Volt × Ampere is the measure of:

- (A) Current
- (B) Volt
- (C) Resistance
- (D) Power

Q157. PHY

The formula $\Phi = \vec{B} \cdot \vec{A}$ represents:

- (A) Electric flux
- (B) Magnetic flux
- (C) Electric flux density
- (D) Gravitational flux

Q158. PHY

Which of the following statement is incorrect for any magnetic field lines?

- (A) Lines start at north pole and ends at south pole
- (B) Lines never touch or cross each other
- (C) The lines are curved
- (D) The magnetic field is strongest when the lines are farthest.

Q159. PHY

The unit of magnetic flux density is:

- (A) $\text{Wb} \cdot \text{m}^{-1}$
- (B) $\text{Wb} \cdot \text{m}$
- (C) $\text{Wb} \cdot \text{m}^{-2}$
- (D) Wb

Q160. PHY

The induced current flow in such a direction so as to oppose the cause that produces it. The statement is:

- (A) Ampere's Law
- (B) Faraday's Law
- (C) Lenz's Law
- (D) Joule's Law

Q161. PHY

In an AC generator the emf will be maximum when factor $\sin \omega t$ is equal to:

- (A) Zero
- (B) 2
- (C) 1
- (D) $1/2$

Q162. PHY

Electric generators and transformers are based on the principles of:

- (A) Coulomb's law
- (B) Faraday's Law
- (C) Ampere's law
- (D) Hooke's law

Q163. PHY

In an ideal transformer:

- (A) Power input is equal to Power output.
- (B) Power input is less than half of the power output.
- (C) Power input is greater than Power output
- (D) Power input is more than half of the power output.

Q164. PHY

The conversion of A.C into D.C is called rectification and circuit is called rectifier. Which component of electronics acts as a rectifier?

- (A) Diode
- (B) Transistor
- (C) Transformer
- (D) Inductor

Q165. PHY

Full wave rectification is given by:

- (A) One diode connected in bridge-type arrangements
- (B) Two diodes connected in bridge-type arrangements
- (C) Three diodes connected in bridge type arrangements
- (D) Four diodes connected in a bridge type arrangement

Q166. PHY

A diode characteristic curve is a plot between:

- (A) Current and time
- (B) Voltage and time
- (C) Voltage and current
- (D) Reverse voltage forward voltage

Q167. PHY

The value of Planck constant is:

- (A) $6.63 \times 10^{-34} \text{ J} \cdot \text{s}$
- (B) $6.63 \times 10^{34} \text{ J} \cdot \text{s}$
- (C) $6.63 \times 10^{-36} \text{ J} \cdot \text{s}$
- (D) $6.63 \times 10^{34} \text{ J} \cdot \text{s}^{-1}$

Q168. PHY

The de-Broglie wavelength associated with a particle moving at 10^6 m/s and having mass 10^{-30} kg is:

- (A) $6.6 \times 10^{-10} \text{ m}$
- (B) $1.5 \times 10^6 \text{ m}$
- (C) $1.9 \times 10^{-5} \text{ m}$
- (D) $7.2 \times 10^{-8} \text{ m}$

Q169. PHY

Light propagates through space as a wave is evident by all of the following EXCEPT:

- (A) Interference
- (B) Photoelectric effect
- (C) Diffraction
- (D) Polarization

Q170. PHY

Which series falls in ultra violet region?

- (A) Lyman
- (B) Brackett
- (C) Pfund
- (D) Paschen

Q171. PHY

The potential through which an electron should be accelerated, so that, on collision it can lift the electron in the atom from its ground state to some higher state is known as:

- (A) Ionization potential
- (B) Excitation potential
- (C) String potential
- (D) Acceleration potential

Q172. PHY

Which of the following regarding X Rays is INCORRECT:

- (A) Have higher wavelength than visible light
- (B) They are part of electromagnetic spectrum
- (C) They are highly penetrating in soft body tissues
- (D) They are high energy photons

Q173. PHY

The unit of decay constant is:

- (A) m
- (B) s
- (C) s^{-1}
- (D) m^{-1}

Q174. PHY

If we have " N_0 " number of any radioactive element then after a period of " n " half-lives the number of atoms left behind is:

- (A) $2^n N_0$
- (B) $(\frac{1}{2})^n N_0$
- (C) $(\frac{1}{2} N_0)^n$
- (D) $(2N_0)^n$

Q175. PHY

Which of the following is NOT the Somatic biological effect of radiation?

- (A) Skin burn
- (B) Loss of hair
- (C) Induction of cancer
- (D) Gene Mutation

Q176. PHY

An artificial radioactive element can be made by bombarding:

- (A) High-energy particles on unstable elements
- (B) Low-energy particles on unstable elements
- (C) High-energy particles on stable elements
- (D) Low-energy particles on stable elements

ENG SECTION: ENGLISH

Questions 177 to 194 (18 MCQs)

Q177. ENG

What does the word "SURPLUS" mean?

- (A) In excess
- (B) A mathematical term
- (C) Within reach
- (D) Salutation

Q178. ENG

What does the word "SPILL" mean?

- (A) Coil
- (B) Deliver
- (C) Spoil
- (D) Spread

Q179. ENG

What does the word "ANCESTOR" mean?

- (A) Collection of stars
- (B) Branch of astrology
- (C) Forefathers
- (D) Type of receptors

Q180. ENG

Choose the correct spellings;

- (A) Pharaoh
- (B) Pharoah
- (C) Pheroh
- (D) Pheraoh

Q181. ENG

The soup _____ good.

- (A) Taste
- (B) Tastes
- (C) Is tasting
- (D) Has taste

Q182. ENG

I _____ him for a long time.

- (A) Have never known
- (B) Had never knew
- (C) Had never been known
- (D) Would never knew

Q183. ENG

_____ words spoken in earnest will convince him.

- (A) A few
- (B) The few
- (C) Few
- (D) Fewer

Q184. ENG

Fill in the blank with appropriate preposition:

He takes _____ his father.

- (A) Up
- (B) Down
- (C) After
- (D) In

Q185. ENG

Pick the correct option.

- (A) The supervisor has nor will ever compromise.
- (B) The supervisor have nor will ever compromise.
- (C) The supervisor has not compromised nor will ever compromise.
- (D) The supervisor has nor will ever compromised.

Q186. ENG

Choose the sentence that is punctuated correctly :

- (A) He said to his disciples "Watch and pray. "
- (B) He said to his disciples, "Watch and pray."
- (C) He said to his disciples, "watch and, pray"
- (D) He said to his disciples' " watch and pray. "

Q187. ENG

Choose the correct sentence.

- (A) She has beauty brains and wealth- a rare combination.
- (B) She has beauty, brains, and wealth: a rare combination.
- (C) She has beauty, brains and wealth- a rare combination.
- (D) She has beauty, brains, and wealth, a rare combination.

Q188. ENG

Choose the correct option according to the subject verb agreement sentence.

- (A) In 1838 Schleiden suggested that all plants were made of cells.
- (B) In 1838 Schleiden suggest that all plants were made of cells.
- (C) In 1838 Schleiden suggested that all plants were make of cells.
- (D) In 1838 Schleiden suggested to all plants were made of cells.

Q189. ENG

Choose the correct sentence.

- (A) It was greatly good by you to proposed day's picnic at murree.
- (B) It was awfully good by you to proposed a day's picnic in Murree.
- (C) It was awfully good of you to propose a day's picnic at Murree.
- (D) It was very good off you too propose days picnic in Murree.

Q190. ENG

Choose the correct sentence

- (A) The first space traveller was Dennis Tito from the United States.
- (B) The First Space Traveller Was Dennis Tito, from, the United states
- (C) The first space traveller was Dennis Tito-from united State
- (D) The first space travaler was Dennis Tito, from the United States

Q191. ENG

Choose the correct sentence

- (A) You have often heard of me speeking of my friend Wahaj waheed a barrister here
- (B) You have often heard me speak of my friend, Wahaj Waheed, who is a barrister here.
- (C) You have often heard me. Speak off my friend, wahaj waheed who is a Barrister here
- (D) You have often heard me speak about my friend ; wahaj waheed-a barrister hear

Q192. ENG

Choose the correct sentence

- (A) "The unexamined life," said Socrates, "is unfit to be lived by man."
- (B) The inexamined life, said Socrates, is unfit to be lived by man"
- (C) "The unexamined life said Socrates" is dsifit to be lived by man.
- (D) The disexamined life" said Socrates is unfit to be lived by man.

Q193. ENG

Choose the correct sentence.

- Ⓐ Gulliver travels was writen to swift.
- Ⓑ Gulliver travels was writen at swift.
- Ⓒ Gulliver's Travels was written by Swift.
- Ⓓ Gulliver's travel was written by swift.

Q194. ENG

Choose the correct sentence:

- Ⓐ There's mr. hashim whome they say is the best portrait painter in the town.
- Ⓑ There's Mr. Hashim, who they say is the best portrait painter in the town.
- Ⓒ There's' Mr. Hashim which they say is the portrait painter in the town.
- Ⓓ There's Mr. Hashim who they say is best portrait painter in the town.

LOGIC SECTION: LOGICAL REASONING

Questions 195 to 200 (6 MCQs)

Q195. LOGIC

Read the following and choose the correct answer :

"P, Q and R are one-digit, non-negative numbers. P is the smallest even number. Q is the largest odd number. R is 5."

- (A) $P + Q + R = 16$
- (B) $P + Q + R = 12$
- (C) $(Q + R) \times P = 30$
- (D) $(Q + R) \times P = 8$

Q196. LOGIC

Statement I: The government has increased the taxes on all businesses in Pakistan.

Statement II: Many small businesses will have to close their operation in Pakistan.

- (A) Statement I is the cause and Statement II is its effect.
- (B) Statement II is the cause and Statement I is its effect.
- (C) Both statements I and II are independent causes.
- (D) Both the statement I and II are the effects of independent causes.

Q197. LOGIC

Read the passage and the following statements below. Then choose the correct option, basing your answer only on the information provided.

"Pakistan is rich in wildlife and culture. It is home to many sorts of wildlife, from the Ibex to the Indus River Dolphin; and people from most countries in the world have made their home here."

Statements:

- i. Pakistan is rich country.
- ii. People from all nationalities of the world live in Pakistan.
- iii. Pakistan is home to at least one dolphin species.

- (A) Only iii statement is correct
- (B) Only i and ii are correct
- (C) Only i and iii are correct
- (D) Only ii and iii are correct

Q198. LOGIC

Observe the pattern and select the next term, in the sequence:

JEQ, HEO, FEM, _____

- (A) GFN
- (B) DEK
- (C) GEL
- (D) DFK

Q199. LOGIC

Read the following and choose the correct answer.

"X, Y and Z are three whole numbers less than 24 but greater than 11. X is the smallest prime number. Y is the largest number divisible by 3. Z is the smallest number divisible by 11."

- (A) X is 13, Y is 24, Z is 11
- (B) X is 13, Y is 21, Z is 22
- (C) X is 11, Y is 21, Z is 11
- (D) X is 11, Y is 24, Z is 22

Q200. LOGIC

All hammers are tools. Some tools are useless things. All useless things are trash. Which of the following is NECESSARILY TRUE given only the information above?

Conclusions:

- I. Some hammers are trash.
- II. Some tools are trash.
- III. All useless things are tools.

- (A) I and III
- (B) I and II
- (C) II and III
- (D) II only

OFFICIAL VERIFIED ANSWER KEY

UHS Lahore MDCAT 2024 Official Paper - Rapid Self-Grading Grid

Online Portal >

Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB
1	A	BIO	41	A	BIO	81	C	CHEM	121	D	CHEM	161	C	PHY
2	A	BIO	42	C	BIO	82	D	CHEM	122	A	CHEM	162	B	PHY
3	B	BIO	43	B	BIO	83	C	CHEM	123	D	PHY	163	A	PHY
4	D	BIO	44	D	BIO	84	C	CHEM	124	A	PHY	164	A	PHY
5	B	BIO	45	C	BIO	85	D	CHEM	125	B	PHY	165	D	PHY
6	C	BIO	46	D	BIO	86	C	CHEM	126	C	PHY	166	C	PHY
7	B	BIO	47	D	BIO	87	A	CHEM	127	C	PHY	167	A	PHY
8	C	BIO	48	C	BIO	88	C	CHEM	128	B	PHY	168	A	PHY
9	D	BIO	49	B	BIO	89	C	CHEM	129	C	PHY	169	B	PHY
10	C	BIO	50	A	BIO	90	D	CHEM	130	A	PHY	170	A	PHY
11	C	BIO	51	B	BIO	91	B	CHEM	131	A	PHY	171	B	PHY
12	B	BIO	52	A	BIO	92	D	CHEM	132	A	PHY	172	A	PHY
13	B	BIO	53	A	BIO	93	C	CHEM	133	B	PHY	173	C	PHY
14	A	BIO	54	C	BIO	94	D	CHEM	134	A	PHY	174	B	PHY
15	C	BIO	55	A	BIO	95	B	CHEM	135	B	PHY	175	D	PHY
16	D	BIO	56	C	BIO	96	A	CHEM	136	D	PHY	176	C	PHY
17	B	BIO	57	D	BIO	97	A	CHEM	137	D	PHY	177	A	ENG
18	A	BIO	58	C	BIO	98	C	CHEM	138	D	PHY	178	D	ENG
19	B	BIO	59	B	BIO	99	B	CHEM	139	D	PHY	179	C	ENG
20	A	BIO	60	A	BIO	100	B	CHEM	140	B	PHY	180	A	ENG
21	A	BIO	61	A	BIO	101	A	CHEM	141	C	PHY	181	B	ENG
22	C	BIO	62	C	BIO	102	A	CHEM	142	C	PHY	182	A	ENG
23	C	BIO	63	C	BIO	103	B	CHEM	143	C	PHY	183	A	ENG
24	C	BIO	64	D	BIO	104	A	CHEM	144	B	PHY	184	C	ENG
25	A	BIO	65	B	BIO	105	B	CHEM	145	B	PHY	185	C	ENG
26	B	BIO	66	A	BIO	106	D	CHEM	146	B	PHY	186	B	ENG
27	C	BIO	67	C	BIO	107	C	CHEM	147	C	PHY	187	B	ENG
28	A	BIO	68	C	BIO	108	B	CHEM	148	C	PHY	188	A	ENG
29	C	BIO	69	D	CHEM	109	A	CHEM	149	B	PHY	189	C	ENG
30	A	BIO	70	B	CHEM	110	B	CHEM	150	B	PHY	190	A	ENG
31	A	BIO	71	C	CHEM	111	C	CHEM	151	B	PHY	191	B	ENG
32	C	BIO	72	B	CHEM	112	B	CHEM	152	A	PHY	192	A	ENG
33	B	BIO	73	C	CHEM	113	B	CHEM	153	C	PHY	193	C	ENG
34	D	BIO	74	D	CHEM	114	D	CHEM	154	C	PHY	194	B	ENG
35	C	BIO	75	B	CHEM	115	B	CHEM	155	B	PHY	195	A	LOGIC
36	B	BIO	76	B	CHEM	116	D	CHEM	156	D	PHY	196	A	LOGIC
37	A	BIO	77	C	CHEM	117	A	CHEM	157	B	PHY	197	A	LOGIC
38	A	BIO	78	B	CHEM	118	C	CHEM	158	D	PHY	198	B	LOGIC
39	A	BIO	79	A	CHEM	119	D	CHEM	159	C	PHY	199	B	LOGIC
40	B	BIO	80	B	CHEM	120	C	CHEM	160	C	PHY	200	D	LOGIC

SUBJECT-WISE PERFORMANCE BREAKDOWN

SUBJECT	MAX	YOUR SCORE	ACCURACY
Biology	68		----- %
Chemistry	54		----- %
Physics	54		----- %
English	18		----- %
Logical Reasoning	6		----- %
TOTAL	200	-----	----- %

PMDC PROVINCIAL MERIT FORMULA

Official Weightage Law:

- MDCAT Component (50%): (Your Score / 200) × 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: (A)

BIOLOGY
12. Nervous Coordination

Which of the following neurotransmitters is lying outside the central nervous system?

CORE CONCEPT & DERIVATION

Neurotransmitters act at synapses in either the central nervous system (CNS) or peripheral nervous system (PNS). Acetylcholine functions as the principal neurotransmitter of the somatic motor neurons and autonomic ganglia in the PNS.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Acetylcholine operates extensively in the peripheral nervous system, specifically at the neuromuscular junction of skeletal muscles and within the parasympathetic nervous system.
- Endorphins, gamma-aminobutyric acid (GABA), and dopamine act predominantly within the brain and spinal cord pathways.

Why other options are incorrect:

- Option B:** Endorphins are neuropeptides localized primarily within the brain and spinal cord that inhibit pain signals.
- Option C:** Gamma-aminobutyric acid (GABA) is the primary inhibitory neurotransmitter confined to the central nervous system.
- Option D:** Dopamine functions predominantly in central neural circuits, including the substantia nigra and basal nuclei.

Question #2 Key: (A)

BIOLOGY
12. Nervous Coordination

Depolarization during conduction of nerve impulse is due to:

CORE CONCEPT & DERIVATION

When a neuron is stimulated past threshold level, voltage-gated sodium channels open rapidly. This causes a massive influx of sodium ions down their electrochemical gradient into the intracellular fluid.

Formula / Rule / Reaction:

Resting potential (-70 mV) $\xrightarrow{\text{Rapid Na}^+ \text{ influx}}$ Action potential (+50 mV)

Solution:

- Upon stimulation, the activation gates of voltage-gated Na^+ channels open.
- The resulting rapid inward movement of Na^+ ions reverses the membrane polarity from negative (-70 mV) to positive (+50 mV), termed depolarization.

Why other options are incorrect:

- Option B:** K^+ ions are already at a higher concentration inside the axoplasm; inward movement does not drive depolarization.
- Option C:** Outward movement of K^+ occurs during repolarization to restore the resting membrane potential.
- Option D:** Outward movement of Na^+ occurs against its gradient via active transport by the Na^+/K^+ ATPase pump, not during depolarization.

Question #3 Key: (B)

BIOLOGY
12. Nervous Coordination

Which of the following is NOT a feature of the autonomic nervous system?

CORE CONCEPT & DERIVATION

The motor division of the peripheral nervous system is split into somatic and autonomic systems. The somatic nervous system controls voluntary skeletal muscles, whereas the autonomic nervous system regulates involuntary effectors.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The autonomic nervous system (ANS) controls involuntary activities by innervating cardiac muscle, smooth muscle, and exocrine/endocrine glands.
- Skeletal muscles are strictly innervated by lower motor neurons of the somatic motor nervous system under conscious control.

Why other options are incorrect:

- Option A:** The ANS innervates and adjusts the metabolic activity of internal visceral organs.
- Option C:** Glandular secretions are directly regulated by sympathetic and parasympathetic divisions of the ANS.
- Option D:** Contraction and relaxation of vascular and visceral smooth muscle are controlled by the ANS.

Question #4 Key: (D)

BIOLOGY
12. Nervous Coordination

Taste receptor is an example of:

CORE CONCEPT & DERIVATION

Sensory receptors are classified based on the nature of the stimulus they transduce. Receptors detecting dissolved chemical molecules are termed chemoreceptors.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Gustatory (taste) receptors in taste buds respond directly to chemical substances dissolved in saliva.
- They convert this chemical interaction into electrical impulses transmitted along sensory cranial nerves to the brain.

Why other options are incorrect:

- Option A:** Mechanoreceptors respond to mechanical pressure, sound waves, or stretch.
- Option B:** Nociceptors are specialized pain receptors responding to tissue damage or noxious stimuli.
- Option C:** Photoreceptors respond exclusively to electromagnetic radiation (light stimuli) in the retina.

Question #5 Key: (B)BIOLOGY
01. Cell

Mesosomes are the invaginations of which bacterial cell structure?

CORE CONCEPT & DERIVATION

In prokaryotic cells, mesosomes are internal, convoluted extensions formed by the infolding of the plasma membrane into the cytoplasm.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The bacterial plasma membrane invaginates to produce vesicular, tubular, or lamellar structures termed mesosomes.
- Mesosomes participate in DNA replication, cell division, and carry enzymes for cellular respiration.

Why other options are incorrect:

- **Option A:** The cell wall is an external rigid peptidoglycan layer that does not form mesosomal infoldings.
- **Option C:** A plasmid is an extrachromosomal circular DNA molecule.
- **Option D:** Cysts are thick-walled dormant survival structures formed by certain bacteria.

Question #6 Key: (C)BIOLOGY
16. Evolution

Which of the following belongs to chordates?

CORE CONCEPT & DERIVATION

Phylum Chordata comprises organisms that possess a notochord, dorsal hollow nerve cord, pharyngeal gill slits, and a post-anal tail at some stage of development.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Trout fish belongs to class Actinopterygii under subphylum Vertebrata, which is part of phylum Chordata.
- In trout, the embryonic notochord is replaced by a cartilaginous or bony vertebral column.

Why other options are incorrect:

- **Option A:** Spiders are invertebrates belonging to class Arachnida of phylum Arthropoda.
- **Option B:** Earthworms are segmented invertebrates belonging to phylum Annelida.
- **Option D:** Starfish are marine deuterostome invertebrates belonging to phylum Echinodermata.

Question #7 Key: (B)BIOLOGY
03. Enzymes

Which of the following statements is incorrect regarding the rate of enzymatic reaction?

CORE CONCEPT & DERIVATION

The rate of an enzyme-catalyzed reaction is directly proportional to enzyme concentration, provided substrate concentration is excess and environmental conditions are constant.

Formula / Rule / Reaction:

$$\text{Rate of reaction} \propto [\text{Enzyme}] \quad (\text{when } [\text{Substrate}] \text{ is non-limiting})$$

Solution:

- Increasing enzyme concentration provides more active sites per unit time for substrate binding, thereby accelerating the reaction velocity.
- Therefore, the assertion that increasing enzyme concentration reduces the rate is factually incorrect.

Why other options are incorrect:

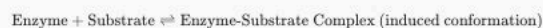
- **Option A:** This is a correct statement describing standard enzyme kinetics with unlimited substrate.
- **Option C:** This is a correct statement; catalytic efficiency reaches its peak at the optimum temperature before denaturation occurs.
- **Option D:** This is a correct statement; each enzyme exhibits maximal velocity at its specific optimum pH.

Question #8 Key: (C)BIOLOGY
03. Enzymes

Induced fit model of enzyme activity suggests that enzyme:

CORE CONCEPT & DERIVATION

Proposed by Daniel Koshland, the induced fit model posits that the active site is flexible and molds around the substrate during binding, which allows some enzymes to accept structurally related substrates.

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

- Unlike the rigid lock-and-key model, the induced fit model accounts for dynamic conformational changes.
- Because the active site adjusts its shape upon substrate contact, the enzyme can accommodate and catalyze reactions for a group of closely related molecular analogues.

Why other options are incorrect:

- **Option A:** The induced fit model explicitly requires that the active site modifies its conformation upon substrate binding.
- **Option B:** Absolute single-substrate specificity is the hallmark of Fischer's rigid lock-and-key model.
- **Option D:** Regulatory allosteric enzymes operate almost exclusively via induced conformational adjustments.

Question #9 Key: (D)BIOLOGY
14. Reproduction

Female reproductive system consists of all of the following EXCEPT:

CORE CONCEPT & DERIVATION

The human female reproductive tract comprises gonads (ovaries), fallopian tubes (oviducts), the uterus with its neck (cervix), and the vagina. Testicular structures belong exclusively to the male reproductive system.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Seminiferous tubules are coiled tubules located within the testicular lobules of the male gonad where spermatogenesis takes place.
- They are entirely absent in females.

Why other options are incorrect:

- **Option A:** Ovaries are the primary female reproductive organs responsible for oogenesis and steroidogenesis.
- **Option B:** Oviducts (fallopian tubes) convey ova from ovaries to the uterus and serve as the site of fertilization.
- **Option C:** The cervix is the lower cylindrical segment of the uterus opening into the vagina.

Question #10 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

Chromosomal abnormality in Turner syndrome is represented by:

CORE CONCEPT & DERIVATION

Turner syndrome is a monosomy resulting from nondisjunction during gametogenesis, leaving the affected female with only one functional X chromosome.

Formula / Rule / Reaction:

$$\text{Karyotype: } 45, X0 \quad (2n - 1 = 45)$$

Solution:

- Individuals with Turner syndrome possess 44 autosomes and a single sex chromosome (X0).
- They develop as phenotypically sterile females characterized by short stature, webbed neck, and undeveloped secondary sexual characteristics.

Why other options are incorrect:

- **Option A:** 47,XXX represents Triplo-X syndrome (super female condition).
- **Option B:** 47,YYY represents Jacobs syndrome.
- **Option D:** 47,XXY represents Klinefelter syndrome in males.

Question #11 Key: (C)BIOLOGY
14. Reproduction

Which one of the following hormones is responsible for the labor pains in a human female at the...

CORE CONCEPT & DERIVATION

Parturition is triggered by neuroendocrine reflexes. Oxytocin released from the posterior pituitary stimulates vigorous contractions of the myometrium, generating labor pains.

Formula / Rule / Reaction:

$$\text{Oxytocin} \xrightarrow{\text{Positive feedback}} \text{Stronger uterine contractions} \rightarrow \text{Labor pains}$$

Solution:

- As the fetal head pushes against the uterine cervix, neural impulses travel to the maternal hypothalamus.
- The posterior pituitary releases oxytocin, which binds to myometrial receptors, inducing contractions that constitute labor pains.

Why other options are incorrect:

- **Option A:** Estrogen increases the sensitivity of uterine muscle to oxytocin by upregulating oxytocin receptors, but does not directly induce rhythmic contractions.
- **Option B:** Progesterone relaxes the myometrium to maintain pregnancy; its levels fall prior to labor.
- **Option D:** Corticosteroids contribute to fetal lung maturation and trigger endocrine cascades, but do not contract the myometrium directly.

Question #12 Key: (B)BIOLOGY
16. Evolution

The change in frequency of alleles at a locus that occurs by chance is known as:

CORE CONCEPT & DERIVATION

Genetic drift is an evolutionary mechanism whereby allele frequencies in a population fluctuate stochastically from one generation to another due to sampling error.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Changes in allele frequencies driven strictly by random chance events, particularly in small populations, define genetic drift.
- Examples include the bottleneck effect and founder effect.

Why other options are incorrect:

- **Option A:** Mutation is a permanent, directional alteration in the nucleotide sequence of DNA.
- **Option C:** Non-random mating changes genotype frequencies through selective partner choice without altering overall allele frequencies by chance alone.
- **Option D:** Speciation is the evolutionary divergence leading to the formation of distinct reproductive species.

Question #13 Key: (B)BIOLOGY
14. Reproduction

Fluid secreted by Sertoli cells provides a liquid medium, protection, and nourishment to:

CORE CONCEPT & DERIVATION

Sertoli cells (sustentacular cells) line the seminiferous tubules and serve as nurse cells that support, protect, and nourish developing male gametes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Sertoli cells secrete testicular fluid into the lumen of seminiferous tubules.
- This fluid provides glucose, amino acids, enzymes, and a liquid vehicle for the nutrition and transport of differentiating spermatids and spermatozoa (sperms).

Why other options are incorrect:

- **Option A:** Oocytes develop in the ovarian follicles of females.
- **Option C:** Polar bodies are small non-functional haploid cells produced during female oogenesis.
- **Option D:** Spermatogonia are the peripheral stem cells resting on the basement membrane; Sertoli fluid specifically nourishes luminal differentiating spermatozoa.

Question #14 Key: (A)BIOLOGY
16. Evolution

Identify the correct pair of vestigial organs:

CORE CONCEPT & DERIVATION

Vestigial organs are anatomical structures that have lost most or all of their ancestral function through evolutionary reduction.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In humans, extrinsic ear muscles (auricular muscles) and the vermiform appendix are classic vestigial remnants.
- Ear muscles no longer function for pinna orientation in humans, and the appendix is a reduced remnant of the ancestral herbivorous caecum.

Why other options are incorrect:

- **Option B:** The heart and liver are indispensable functional organs responsible for circulation and metabolic homeostasis.
- **Option C:** The liver is a fully functional metabolic organ.
- **Option D:** The heart is a functional muscular organ.

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

Which of the following increases variation within a gene pool?

CORE CONCEPT & DERIVATION

A gene pool represents the total aggregate of all genes and alleles in a population. While sexual processes reshuffle existing alleles, novel genetic variations and new alleles can only originate through mutations.

Formula / Rule / Reaction:

$$\text{New Alleles in Gene Pool} = f(\text{Gene Mutation})$$

Solution:

- Gene mutation alters nucleotide sequences, introducing completely new alleles that expand the overall diversity of the gene pool.
- Crossing over and random fusion of gametes generate new phenotypic combinations of existing alleles, but cannot generate novel alleles.
- **Note on Board Key:** The official UHS 2024 key marked Option C, as mutations are the primary source of variation within a gene pool according to the Punjab Textbook. Some candidates contested for Option B (Crossing over).

Why other options are incorrect:

- **Option A:** Chromosome inversion rearranges gene order on a chromosome without adding new alleles to the gene pool.
- **Option B:** Crossing over reshuffles existing parental alleles during meiosis rather than introducing new alleles.
- **Option D:** Random fusion combines preexisting gametes into new zygotic genotypes without creating new alleles.

Question #16 Key: (D)BIOLOGY
14. Reproduction

Corpus luteum during female reproductive cycle produces:

CORE CONCEPT & DERIVATION

After ovulation, the collapsed Graafian follicle transforms under the influence of LH into a glandular endocrine body termed the corpus luteum, which acts as the major source of progesterone.

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

- Luteal cells of the corpus luteum secrete large quantities of progesterone and minor amounts of estrogen.
- Progesterone prepares the endometrium for implantation and inhibits pituitary secretion of FSH and LH.

Why other options are incorrect:

- **Option A:** Testosterone is an androgen produced primarily by testicular Leydig cells in males.
- **Option B:** Follicle stimulating hormone (FSH) is synthesized and secreted by the anterior pituitary gland.
- **Option C:** Luteinizing hormone (LH) is produced by gonadotroph cells in the anterior pituitary.

Question #17 Key: (B)BIOLOGY
16. Evolution

Which of the following statements about natural selection is not true?

CORE CONCEPT & DERIVATION

Natural selection is differential reproductive success driven by environmental pressures. Selection imposed deliberately by human breeders is termed artificial selection.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Breeders selectively mate organisms for desired commercial traits, which defines artificial selection.
- Natural selection operates strictly without human intervention through ecological interactions.

Why other options are incorrect:

- **Option A:** Natural selection can act only on phenotypic traits that have a heritable genetic basis.
- **Option C:** By favoring advantageous alleles, natural selection increases the adaptation of a population to its environment.
- **Option D:** Environmental pressures vary geographically, making natural selection regional and context-dependent.

Question #18 Key: (A)BIOLOGY
16. Evolution

The formula calculating the frequency of genotypes and alleles in a population gene pool is known as...

CORE CONCEPT & DERIVATION

The Hardy-Weinberg principle states that allele and genotype frequencies in a large, randomly mating population remain constant from generation to generation in the absence of evolutionary forces.

Formula / Rule / Reaction:

$$p + q = 1 \quad \text{and} \quad p^2 + 2pq + q^2 = 1$$

Solution:

- The binomial expansion represents the frequencies of homozygous dominant (p^2), heterozygous ($2pq$), and homozygous recessive (q^2) genotypes.
- This algebraic formulation is the Hardy-Weinberg equation.

Why other options are incorrect:

- **Option B:** Lamarck proposed the non-mathematical theory of inheritance of acquired characteristics.
- **Option C:** Darwin proposed the theory of evolution by natural selection without a mathematical equation.
- **Option D:** James Hutton proposed the geological principle of uniformitarianism.

Question #19 Key: (B)BIOLOGY
14. Reproduction

Due to the process of follicle atresia:

CORE CONCEPT & DERIVATION

During each ovarian cycle in humans, multiple primordial follicles begin maturation, but only one dominant follicle ovulates while the rest undergo programmed degeneration termed follicular atresia.

Formula / Rule / Reaction:

$$\text{Non-dominant ovarian follicles} \xrightarrow{\text{Apoptosis}} \text{Follicular atresia (degeneration)}$$

Solution:

- Follicle atresia is the apoptotic breakdown and resorption of immature ovarian follicles.
- Hence, atresia causes the follicle to degenerate.

Why other options are incorrect:

- **Option A:** Only the selected dominant Graafian follicle attains maximum size and antrum development.
- **Option C:** Ovulation is the rupture of the mature follicle, which is the opposite of atretic degeneration.
- **Option D:** Follicular maturation is stimulated by FSH, whereas atresia marks the arrest and demise of follicular growth.

Question #20 Key: (A)BIOLOGY
16. Evolution

The idea of inheritance of acquired characteristics was presented by:

CORE CONCEPT & DERIVATION

Jean-Baptiste de Lamarck published his evolutionary theory in 1809 in 'Philosophie Zoologique', proposing that modifications acquired during an organism's lifetime could be transmitted to progeny.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Lamarck proposed two main ideas: the law of use and disuse, and the inheritance of acquired characters.
- He hypothesized that physiological adaptations (such as neck lengthening in giraffes) are inherited directly.

Why other options are incorrect:

- **Option B:** Charles Darwin formulated the theory of evolution through natural selection acting on preexisting variations.
- **Option C:** Thomas Malthus wrote an essay on population growth that influenced evolutionary thinking.
- **Option D:** Alfred Russel Wallace independently formulated the theory of natural selection.

Question #21 **Key: (A)**BIOLOGY
14. Reproduction*Main function of the epididymis is to:***CORE CONCEPT & DERIVATION**

The epididymis is a convoluted tubular organ capping the posterior margin of each testis. Its physiological roles include sperm storage, functional maturation, and transport toward the vas deferens.

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

- According to the Punjab Textbook Board, the epididymis acts as a physiological duct system that stores spermatozoa and transports them from the vasa efferentia into the vas deferens.
- In the official UHS answer key, Option A is designated as correct.

Why other options are incorrect:

- **Option B:** The vas deferens and ejaculatory duct connect to the urethra, not the epididymis directly.
- **Option C:** Semen fluid is produced predominantly by the accessory glands (seminal vesicles, prostate, and bulbourethral glands).
- **Option D:** Spermatogenesis occurs strictly within the seminiferous tubules of the testes, not in the epididymis.

Question #22 **Key: (C)**BIOLOGY
16. Evolution*According to endosymbiosis theory, flagella may have been derived by the ingestion of prokaryot...***CORE CONCEPT & DERIVATION**

Lynn Margulis' serial endosymbiotic theory proposes that eukaryotic organelles originated via the ingestion of symbiotic prokaryotes by ancestral anaerobic host cells.

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

- Under the endosymbiosis hypothesis, eukaryotic flagella and cilia (undulipodia) arose through symbiotic association with motile, spiral prokaryotes resembling spirochetes.
- Mitochondria derived from purple non-sulfur aerobic bacteria, and chloroplasts derived from cyanobacteria.

Why other options are incorrect:

- **Option A:** Amoeboid cells are eukaryotic or primitive protozoans, not prokaryotic ancestors of flagella.
- **Option B:** Ingestion of aerobic bacteria led to the evolution of mitochondria.
- **Option D:** Spirillum represents a genus of rigid helical bacteria that did not serve as the model for undulipodia in endosymbiotic theory.

Question #23 **Key: (C)**BIOLOGY
14. Reproduction*Immediate next stage of spermatogonia differentiation is:***CORE CONCEPT & DERIVATION**

Spermatogenesis follows a strict sequence: spermatogonia divide mitotically and differentiate into primary spermatocytes, which then enter meiosis.

Formula / Rule / Reaction:

Spermatogonium (2n) $\xrightarrow{\text{Mitosis / Growth}}$ Primary Spermatocyte (2n) $\xrightarrow{\text{Meiosis I}}$ Secondary Spermatocyte

Solution:

- Type B spermatogonia grow and accumulate cytoplasm to differentiate into diploid primary spermatocytes.
- Therefore, the primary spermatocyte is the immediate next developmental stage.

Why other options are incorrect:

- **Option A:** Secondary spermatocytes form only after primary spermatocytes complete the first meiotic division.
- **Option B:** Spermatids result from the completion of meiosis II by secondary spermatocytes.
- **Option D:** Mature sperms (spermatozoa) arise after spermatids undergo spermiogenesis.

Question #24 **Key: (C)**BIOLOGY
13. Chemical Coordination*Insulin converts glucose into:***CORE CONCEPT & DERIVATION**

Insulin is an anabolic hormone secreted by pancreatic beta cells. Beyond stimulating glycogen synthesis, insulin promotes lipogenesis, converting excess blood glucose into fatty acids and triglycerides (lipids).

Formula / Rule / Reaction:

Excess Glucose $\xrightarrow{\text{Insulin}}$ Acetyl-CoA $\xrightarrow{\text{Lipogenesis}}$ Triglycerides (Lipids)

Solution:

- When glycogen stores in liver and muscle are saturated, insulin stimulates the uptake of glucose by adipose tissue and liver.
- Glucose is metabolized to glycerol-3-phosphate and acetyl-CoA to synthesize triglycerides and lipids for long-term energy storage.

Why other options are incorrect:

- **Option A:** Vitamins are essential micronutrients obtained through diet and cannot be synthesized from glucose via insulin.
- **Option B:** Minerals are inorganic chemical elements that cannot be synthesized by biochemical pathways.
- **Option D:** Cortisone is a steroid hormone synthesized from cholesterol in the adrenal cortex, not from glucose by insulin.

Question #25 Key: (A)BIOLOGY
11. Support & Movement

Which of the following is included in paired cranial bones?

CORE CONCEPT & DERIVATION

The human cranium consists of 8 bones: two paired bones (temporal and parietal) and four unpaired bones (frontal, occipital, sphenoid, and ethmoid).

Formula / Rule / Reaction:

Cranium (8 bones) = Parietal (2) + Temporal (2) + Frontal (1) + Occipital (1) + Sphenoid (1) + Ethmoid (1)

Solution:

- The temporal bones form the lateral sides and base of the cranium and exist as a symmetrical pair (right and left).
- Frontal and occipital bones are single, unpaired cranial bones.

Why other options are incorrect:

- **Option B:** The occipital bone is an unpaired bone situated at the posterior inferior region of the neurocranium.
- **Option C:** The frontal bone is a single, unpaired cranial bone forming the forehead.
- **Option D:** The vomer is an unpaired facial bone forming part of the nasal septum, not a paired cranial bone.

Question #26 Key: (B)BIOLOGY
09. Respiration / Gaseous Exchange

About 70% of the carbon dioxide is carried in blood as:

CORE CONCEPT & DERIVATION

Carbon dioxide is transported in blood in three forms: dissolved in plasma (7%), bound to hemoglobin as carbamino hemoglobin (23%), and as bicarbonate ions (70%).

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

- Within erythrocytes, carbonic anhydrase hydrates CO_2 to form carbonic acid, which dissociates into hydrogen and bicarbonate ions (HCO_3^-).
- Bicarbonate diffuses out into the blood plasma via the chloride shift, transporting approximately 70% of total CO_2 .

Why other options are incorrect:

- **Option A:** Carbonate (CO_3^{2-}) does not exist in physiological blood pH ranges in significant amounts.
- **Option C:** Tricarbonate is a non-existent chemical species in blood physiology.
- **Option D:** Carbonic anhydrase is the catalytic metalloenzyme inside erythrocytes, not a transport vehicle.

Question #27 Key: (C)BIOLOGY
11. Support & Movement

Which of the following skeletal disorders is an example of an autoimmune disorder?

CORE CONCEPT & DERIVATION

An autoimmune disorder occurs when the immune system fails to recognize self-antigens and attacks healthy host tissues. In the skeletal system, rheumatoid arthritis represents a chronic inflammatory autoimmune disease.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In rheumatoid arthritis, antibodies (such as rheumatoid factor and anti-CCP) attack the synovial membranes of joints.
- This produces chronic synovitis, pannus formation, cartilage erosion, and eventual joint deformities.

Why other options are incorrect:

- **Option A:** Sciatica is a neurological pain condition caused by compression or irritation of the sciatic nerve.
- **Option B:** Spondylosis is a degenerative, age-related wear-and-tear condition of the spinal vertebrae.
- **Option D:** Rickets is a nutritional deficiency disorder in children caused by a lack of vitamin D, calcium, or phosphate.

Question #28 Key: (A)BIOLOGY
09. Respiration / Gaseous Exchange

Range of normal total lung capacity in humans is:

CORE CONCEPT & DERIVATION

Total lung capacity (TLC) is the maximum volume of gas to which the lungs can be expanded with the greatest possible inspiratory effort.

Formula / Rule / Reaction:

$$\text{TLC} = \text{Vital Capacity (VC)} + \text{Residual Volume (RV)} \approx 4.5 \text{ L} + 1.2 \text{ L} \approx 5.7 \text{ L}$$

Solution:

- In a healthy adult human, total lung capacity typically ranges between 5.0 and 6.0 liters (5000 to 6000 mL).
- TLC is influenced by factors such as age, sex, body height, and athletic conditioning.

Why other options are incorrect:

- **Option B:** 8–9 liters substantially exceeds normal human physiological lung volumes.
- **Option C:** 10–11 liters represents an unphysiological, grossly exaggerated value for humans.
- **Option D:** 12–13 liters is seen in large marine mammals, not human beings.

Question #29 Key: (C)BIOLOGY
11. Support & Movement

Which feature is possessed by smooth muscles?

CORE CONCEPT & DERIVATION

Muscle tissues are classified as skeletal, cardiac, or smooth based on morphology and innervation. Smooth muscle cells are spindle-shaped (fusiform), non-striated, involuntary, and contain a single centrally placed nucleus.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Smooth muscle myocytes are uninucleate cells lacking sarcomeric striations.
- They are located within the walls of hollow internal organs such as the gut, bladder, and blood vessels.

Why other options are incorrect:

- **Option A:** Smooth muscle contraction is involuntary and regulated by the autonomic nervous system.
- **Option B:** Branched muscle fibers are characteristic of cardiac muscle tissue.
- **Option D:** Smooth muscle lacks the alternating A and I bands that create a striated appearance in skeletal and cardiac muscle.

Question #30 Key: (A)BIOLOGY
04. BioenergeticsRespiration in *Pseudomonas* bacteria is:**CORE CONCEPT & DERIVATION**

Bacteria exhibit diverse respiratory adaptations depending on their oxygen requirements. *Pseudomonas* species are classified physiologically as obligate (strict) aerobes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- *Pseudomonas* uses molecular oxygen as the terminal electron acceptor in its respiratory electron transport chain.
- According to the Punjab Textbook Board, *Pseudomonas* is a standard example of an obligate aerobic bacterium.

Why other options are incorrect:

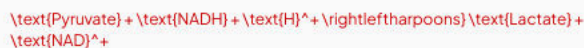
- **Option B:** Obligate anaerobes (e.g., *Clostridium*) survive only in the absence of oxygen.
- **Option C:** Facultative anaerobes (e.g., *Escherichia coli*) can grow with or without molecular oxygen.
- **Option D:** Microaerophiles (e.g., *Campylobacter*) require very low concentrations of oxygen (2–10%).

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

The accumulation of 'lactic acid' in the muscles results in:

CORE CONCEPT & DERIVATION

During strenuous anaerobic exercise, muscles generate ATP via lactic acid fermentation. The buildup of lactic acid lowers axoplasmic and intracellular pH, precipitating muscle fatigue.

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

- Accumulation of lactic acid reduces intramuscular pH and inhibits glycolytic enzymes such as phosphofructokinase.
- This causes the sensation of muscle soreness and extreme muscle fatigue, preventing further sustained contraction.

Why other options are incorrect:

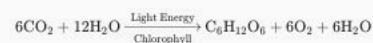
- **Option B:** Contraction requires ATP and free Ca^{2+} ; lactic acid accumulation inhibits actin-myosin interaction rather than causing sustained contraction.
- **Option C:** Paralysis is caused by severe loss of motor neuron function, not reversible metabolic fatigue.
- **Option D:** Convulsions are violent, involuntary muscle spasms resulting from aberrant electrical discharge in the brain.

Question #32 Key: (C)BIOLOGY
06. Digestion/Nutrition

The autotrophic mode of nutrition in an organism depends upon the following:

CORE CONCEPT & DERIVATION

Autotrophic organisms synthesize organic food molecules from inorganic raw materials using an external energy source. In green plants and algae, this occurs through the process of photosynthesis.

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

- Autotrophic nutrition converts solar radiation into biochemical bond energy using light-absorbing pigments.
- Therefore, autotrophy directly depends upon the photosynthetic mode (or chemosynthetic mode in certain bacteria).

Why other options are incorrect:

- **Option A:** Saprotrophic nutrition is a heterotrophic mode in which nutrients are absorbed from decaying organic matter.
- **Option B:** Parasitic nutrition is a heterotrophic mode where an organism derives nourishment at the expense of a living host.
- **Option D:** 'Obligate mode' describes a survival dependency (e.g., obligate parasite) rather than a nutritional pathway for food synthesis.

Question #33 Key: (B)BIOLOGY
11. Support & Movement

Thick filaments in skeletal muscles are composed of:

CORE CONCEPT & DERIVATION

The sarcomere of striated muscle contains two major types of myofilaments: thick filaments composed of myosin and thin filaments composed primarily of actin.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Thick filaments are cylindrical bundles composed of several hundred molecules of the protein myosin.
- Each myosin molecule possesses a fibrous tail and two globular heads that form cross-bridges with actin during contraction.

Why other options are incorrect:

- Option A:** Actin is the primary globular protein forming the backbone of thin filaments.
- Option C:** Tropomyosin is a regulatory filament that wraps around the actin helix within thin filaments.
- Option D:** Troponin is a regulatory protein complex attached to tropomyosin on thin filaments.

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

Prokaryotic cells lack:

CORE CONCEPT & DERIVATION

Prokaryotes (bacteria and archaea) are distinguished structurally by the absence of a true membrane-delimited nucleus and membrane-bound cytoplasmic organelles.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Membrane-bound compartments such as mitochondria, endoplasmic reticulum, chloroplasts, and Golgi bodies are strictly confined to eukaryotic cells.
- Prokaryotes carry out metabolic processes in the cytoplasm or across the cell membrane.

Why other options are incorrect:

- Option A:** Mesosomes are common membranous infoldings present in bacteria.
- Option B:** Ribosomes (70S) are universally present in prokaryotic cells for protein translation.
- Option C:** Storage bodies (inclusion granules of glycogen, polyphosphate, or lipid) are present in bacterial cytoplasm.

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

Bacterial genome becomes diploid:

CORE CONCEPT & DERIVATION

Bacteria possess a single circular haploid chromosome. During vegetative binary fission, replication of the circular chromosome produces two identical copies within the same cytoplasm prior to cytokinesis.

Formula / Rule / Reaction:

$$1 \text{ Chromosome} \xrightarrow{\text{DNA Replication}} 2 \times \text{Chromosomes in one cell (transient diploid)}$$

Solution:

- During binary fission, the single circular DNA molecule replicates bidirectionally from the origin of replication.
- Until cell separation occurs, the bacterium temporarily contains two complete genomes, rendering it functionally diploid.
- Note on Board Key:** UHS officially keyed Option C based on this replication phase during binary fission.

Why other options are incorrect:

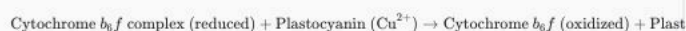
- Option A:** Bacteria reproduce asexually and do not undergo syngamy or gametic fertilization.
- Option B:** Spore formation packages a single haploid genomic copy into a dehydrated endospore coat.
- Option D:** Following binary fission, each separated daughter bacterium receives one chromosome, restoring the haploid state.

Question #36 Key: (B)BIOLOGY
04. Bioenergetics

In the journey of electrons from photosystem II to photosystem I plastocyanin is reduced by:

CORE CONCEPT & DERIVATION

In non-cyclic photophosphorylation (Z-scheme), electrons pass down an electron transport chain from PS II to PS I. Plastocyanin is a mobile, copper-containing protein that accepts electrons directly from the cytochrome complex.

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

- Electrons travel from Plastoquinone to the Cytochrome b_6f complex.
- The reduced cytochrome complex then transfers electrons directly to plastocyanin, thereby reducing Cu^{2+} to Cu^{+} .
- Plastocyanin subsequently delivers these electrons to oxidize P_{700} in PS I.

Why other options are incorrect:

- Option A:** Plastoquinone reduces the cytochrome complex, not plastocyanin directly.
- Option C:** P_{700} receives electrons from reduced plastocyanin; plastocyanin reduces P_{700} , not vice versa.
- Option D:** The primary electron acceptor of PS I accepts electrons excited from P_{700} and passes them to ferredoxin.

Question #37 **Key: (A)**BIOLOGY
04. Bioenergetics

Enzyme NADP reductase is responsible for:

CORE CONCEPT & DERIVATION

NADP⁺ reductase (ferredoxin-NADP⁺ oxidoreductase) is the terminal enzyme of the photosynthetic electron transport chain located on the stromal side of the thylakoid membrane.

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

- The enzyme accepts electrons from reduced ferredoxin and transfers them to NADP⁺.
- This reduces NADP⁺ into NADPH, the reducing power needed for the Calvin cycle.

Why other options are incorrect:

- **Option B:** The enzyme reduces NADP⁺ rather than oxidizing it; NADPH is oxidized later in the stroma by Calvin cycle enzymes.
- **Option C:** Ferredoxin is oxidized (not reduced) when it transfers its electron to the reductase.
- **Option D:** P₇₀₀ is reduced by plastocyanin, not by NADP⁺ reductase.

Question #38 **Key: (A)**BIOLOGY
04. Bioenergetics

The PS II, during light reactions, receives electrons from splitting:

CORE CONCEPT & DERIVATION

When the reaction center chlorophyll P₆₈₀ of photosystem II is photo-oxidized, the electron hole is refilled by electrons extracted from water photolysis.

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

- The oxygen-evolving complex associated with PS II catalyzes the catalytic photolysis of water.
- Electrons released from water are transferred to P₆₈₀⁺ to restore its ground state, releasing oxygen as a byproduct.

Why other options are incorrect:

- **Option B:** Plastoquinone accepts electrons downstream from the primary electron acceptor of PS II.
- **Option C:** Plastocyanin supplies electrons to PS I, not PS II.
- **Option D:** Ferredoxin operates near the terminus of PS I electron transport.

Question #39 **Key: (A)**BIOLOGY
02. Biomolecules

Mono-saccharides have a general formula represented by:

CORE CONCEPT & DERIVATION

Monosaccharides are simple sugars that cannot be hydrolyzed into simpler carbohydrates. They exhibit a stoichiometric carbon to water ratio of 1:1.

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

- The empiric formula for monosaccharides is (CH₂O)_n, representing a 1:2:1 ratio of carbon, hydrogen, and oxygen atoms.
- For trioses $n = 3$ (C₃H₆O₃), hexoses $n = 6$ (C₆H₁₂O₆).

Why other options are incorrect:

- **Option B:** C(H₂O)_n incorrect specifies only a single carbon atom attached to n water units.
- **Option C:** C₂(H₂O)_n incorrect fixes the carbon count to two regardless of chain length.
- **Option D:** C_x(H₂O)_y is the general formula applied to oligosaccharides and complex polysaccharides where $x \neq y$.

Question #40 **Key: (B)**BIOLOGY
02. Biomolecules

What is the percentage of [Formula] in bone cells?

CORE CONCEPT & DERIVATION

Water content varies across human biological tissues based on cellularity and matrix mineralization. Bone tissue possesses a highly mineralized extracellular matrix.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- According to the Punjab Textbook Board (Biology Book 1, Chapter 2: Biological Molecules), the water content of bone cells is approximately 20%.
- In comparison, soft high-metabolism tissues like brain cells contain approximately 85% water.

Why other options are incorrect:

- **Option A:** 70% represents the overall average water percentage of total body weight in adults.
- **Option C:** 99% water content is found in structures like jellyfish or vitreous humor, not dense bone tissue.
- **Option D:** 60% represents intracellular fluid fraction or general soft tissue hydration.

Question #41 Key: (A)BIOLOGY
02. Biomolecules

When glycerol reacts with fatty acid, which type of chemical bond will form?

CORE CONCEPT & DERIVATION

Acylglycerols (fats and oils) are synthesized via condensation reactions between the hydroxyl groups of glycerol and the carboxyl groups of fatty acids.

Formula / Rule / Reaction:



Solution:

- The chemical bond between the carboxyl carbon of the fatty acid and the oxygen of the glycerol hydroxyl group is an ester bond.
- Formation of one triacylglycerol molecule results in three ester linkages with the release of three water molecules.

Why other options are incorrect:

- Option B:** Ether linkages (R-O-R') occur in archaeal membrane lipids, not in ester-linked eukaryotic glycerides.
- Option C:** Hydrogen bonds are weak non-covalent electrostatic interactions.
- Option D:** Ionic bonds involve electrostatic attraction between permanent cations and anions, which does not characterize covalent triglycerides.

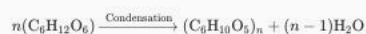
Question #42 Key: (C)BIOLOGY
02. Biomolecules

Polysaccharides in plants are synthesized by the process of:

CORE CONCEPT & DERIVATION

Biological macromolecules are synthesized from monomeric units via condensation (dehydration synthesis), in which a water molecule is eliminated as each covalent bond forms.

Formula / Rule / Reaction:



Solution:

- Starch and cellulose are formed by linking monosaccharide (glucose) units via glycosidic bonds.
- Because this joining involves the removal of H and OH as H₂O, the synthesis is a condensation reaction.

Why other options are incorrect:

- Option A:** Hydrolysis breaks down polymers into monomers by consuming water.
- Option B:** Oxidation involves the loss of electrons or hydrogen, typical of respiratory catabolism.
- Option D:** Glycolysis is a 10-step catabolic pathway that cleaves glucose into pyruvate.

Question #43 Key: (B)BIOLOGY
02. Biomolecules

Which of the following process is involved in breakdown of protein into Amino acids?

CORE CONCEPT & DERIVATION

Proteins consist of amino acids joined by peptide bonds. Enzymatic cleavage of peptide bonds during digestion requires the addition of water molecules, termed hydrolysis.

Formula / Rule / Reaction:



Solution:

- Hydrolysis consumes a molecule of water to restore the carboxylic acid and amino functional groups of constituent amino acids.
- Proteolytic enzymes such as pepsin, trypsin, and chymotrypsin catalyze this hydrolytic breakdown.

Why other options are incorrect:

- Option A:** Condensation is an anabolic process that joins amino acids to synthesize polypeptide chains.
- Option C:** Glycolysis catabolizes glucose into pyruvate.
- Option D:** Fixation refers to inorganic element assimilation, such as carbon or nitrogen fixation.

Question #44 Key: (D)BIOLOGY
11. Support & Movement

Sarcomere is part of myofibril between:

CORE CONCEPT & DERIVATION

The sarcomere is the basic structural and functional repeating contractile unit of striated muscle fibrils.

Formula / Rule / Reaction:

Sarcomere = Region from one Z-line to the next consecutive Z-line

Solution:

- A myofibril is divided along its length into repetitive units called sarcomeres.
- The boundaries defining each sarcomere are dense protein discs termed Z-lines (or Z-discs).
- Each sarcomere contains one full A-band and two half I-bands.

Why other options are incorrect:

- Option A:** Z-lines bisect the I bands; sarcomeres are not defined as the distance between two I bands.
- Option B:** Each sarcomere contains only a single central A band.
- Option C:** The M line is the central anchoring protein line inside the A band; a sarcomere does not span between two M lines.

Question #45 Key: (C)BIOLOGY
01. Cell*Chloroplast are membrane bound bodies containing:***CORE CONCEPT & DERIVATION**

Chloroplasts are double-membrane photosynthetic plastids that contain light-absorbing pigments embedded in thylakoid membranes.

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

- Chloroplasts are distinguished from other plastids (like leucoplasts) by their content of photosynthetic pigments, principally chlorophyll a, chlorophyll b, and carotenoids.
- These pigments absorb photosynthetically active radiation to drive electron transport.

Why other options are incorrect:

- Option A:** Although chloroplasts contain stroma enzymes, pigments are the unique distinguishing constituent characterizing chloroplasts among double-membrane plastids.
- Option B:** Cisternae are the flattened membranous stacks characteristic of the endoplasmic reticulum and Golgi complex.
- Option D:** Cristae are internal foldings of the inner mitochondrial membrane.

Question #46 Key: (D)BIOLOGY
01. Cell*Which of the following is the function of Golgi Complex?***CORE CONCEPT & DERIVATION**

The Golgi apparatus functions as the processing, packaging, and sorting station of the eukaryotic cell.

Formula / Rule / Reaction:

ER Products → cis-Golgi $\xrightarrow{\text{Post-translational modification}}$ trans-Golgi → Secretory Vesicles

Solution:

- Proteins and lipids arriving from the rough and smooth endoplasmic reticulum undergo glycosylation and phosphorylation in the Golgi cisternae.
- The modified products are packaged into membrane-bound secretory vesicles for target delivery or exocytosis.

Why other options are incorrect:

- Option A:** Intracellular digestion is carried out by lysosomes containing hydrolytic acid hydrolases.
- Option B:** Autophagy (organelle recycling) is mediated by autophagosomes fusing with lysosomes.
- Option C:** Autolysis (cellular self-destruction) is triggered by the rupture of lysosomal contents into the cytosol.

Question #47 Key: (D)BIOLOGY
02. Biomolecules*The hydrophilic end of the phospholipid molecule is polar because of the presence of:***CORE CONCEPT & DERIVATION**

Phospholipids are amphipathic molecules consisting of two hydrophobic fatty acid tails and a hydrophilic head group that carries an ionized phosphate moiety.

Formula / Rule / Reaction:

Phospholipid Head = Glycerol + Phosphate Group (PO_4^{3-}) + Nitrogenous Base

Solution:

- The phosphate group carries negative charges at physiological pH.
- This formal charge makes the head region polar and capable of forming favorable hydrogen bonds with surrounding water molecules.

Why other options are incorrect:

- Option A:** Glycerol provides the 3-carbon backbone linking the tails and head, but the primary polarity arises from the charged phosphate group.
- Option B:** An amine group (like choline or ethanolamine) may be attached, but not all phospholipids contain an amine, whereas all contain a polar phosphate group.
- Option C:** Fatty acids form the non-polar, hydrophobic hydrocarbon tails.

Question #48 Key: (C)BIOLOGY
12. Nervous Coordination*Nissl's granules are groups of:***CORE CONCEPT & DERIVATION**

Nissl granules (Nissl bodies) are prominent granular structures found in the soma and proximal dendrites of neurons that stain intensely with basic histological dyes.

Formula / Rule / Reaction:

Nissl Granules = Rough Endoplasmic Reticulum + Ribosomes (Polysomes)

Solution:

- Ultrastructural electron microscopy shows that Nissl granules consist of dense aggregations of rough endoplasmic reticulum and free ribosomes.
- They synthesize proteins, structural peptides, and neurotransmitter enzymes required by neurons.

Why other options are incorrect:

- Option A:** Mesosomes are prokaryotic membranous structures found in bacteria.
- Option B:** Lysosomes are single-membrane lytic vesicles containing hydrolytic enzymes.
- Option D:** Chromosomes are nuclear structures composed of DNA and histone proteins.

Question #49 Key: (B)BIOLOGY
02. Biomolecules

Which monosaccharide will form a gluco-pyranose ring in solution?

CORE CONCEPT & DERIVATION

In aqueous solution, aldohexoses undergo intramolecular hemiacetal formation between the C-1 aldehyde group and the C-5 hydroxyl group, forming a 6-membered pyranose ring.

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

- Glucose is an aldohexose that predominantly cyclizes into a six-membered ring containing five carbon atoms and one oxygen atom.
- This stable six-membered cyclic hemiacetal is called glucopyranose.

Why other options are incorrect:

- Option A:** Fructose is a ketohexose that forms a 5-membered furanose ring (fructofuranose).
- Option C:** Ribose is an aldopentose that forms a 5-membered furanose ring (ribofuranose).
- Option D:** Deoxyribose forms a 5-membered furanose ring.

Question #50 Key: (A)BIOLOGY
01. Cell

The nucleus takes dyes due to the presence of:

CORE CONCEPT & DERIVATION

The term chromatin (derived from Greek 'chroma', meaning color) was coined by Walther Flemming due to its strong affinity for basic biological dyes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Chromatin consists of negatively charged DNA associated with basic histone proteins.
- The negatively charged phosphate backbones of DNA bind cationic dyes (such as acetocarmine, basic fuchsin, and hematoxylin), allowing the nucleus to be stained and visualized.

Why other options are incorrect:

- Option B:** Lipids are located primarily in nuclear membranes and do not bind standard basic nuclear stains.
- Option C:** Trace metal ions do not confer the basophilic staining characteristic of the nucleoplasm.
- Option D:** Thylakoids are photosynthetic sub-compartments found inside plant chloroplasts, not inside the cell nucleus.

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

The organelles only found at seedling stage in oil seed plants are:

CORE CONCEPT & DERIVATION

Glyoxysomes are specialized microbodies containing enzymes of the glyoxylate cycle that convert stored fatty acids into carbohydrates during seed germination.

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

- In oil-storing germinating seeds (such as castor bean, soybean, and sunflower), stored triacylglycerols must be mobilized into soluble sugars before photosynthesis begins.
- Glyoxysomes contain isocitrate lyase and malate synthase, allowing gluconeogenesis from lipids specifically during early seedling development.

Why other options are incorrect:

- Option A:** Peroxisomes are permanently present in most plant cells and animal cells, performing photorespiration and peroxide decomposition.
- Option C:** Microbodies is an umbrella category that includes both peroxisomes and glyoxysomes, not a specific organelle exclusive to lipid-rich seedlings.
- Option D:** Vacuoles are permanent, universal organelles found across all developmental stages of plant cells.

Question #52 Key: (A)BIOLOGY
13. Chemical Coordination

Posterior lobe of pituitary produce:

CORE CONCEPT & DERIVATION

The neurohypophysis (posterior pituitary) stores and releases peptide neurohormones synthesized by magnocellular neurons located in the supraoptic and paraventricular nuclei of the hypothalamus.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Antidiuretic hormone (ADH, or vasopressin) and oxytocin are axonally transported from the hypothalamus and secreted into the bloodstream by the posterior lobe of the pituitary gland.
- Although biologically synthesized in the hypothalamus, the posterior pituitary is universally tested as the functional releasing site of ADH in the provincial curriculum.

Why other options are incorrect:

- Option B:** Thyroid-stimulating hormone (TSH) is produced and secreted by thyrotrope cells of the anterior pituitary gland.
- Option C:** Adrenocorticotropic hormone (ACTH) is synthesized by corticotrope cells of the anterior pituitary.
- Option D:** Follicle-stimulating hormone (FSH) is produced by gonadotrope cells of the anterior pituitary.

Question #53 **Key: (A)**BIOLOGY
12. Nervous Coordination

In human myelinated fibres nerve impulse travels at _____ meters per second.

CORE CONCEPT & DERIVATION

Saltatory conduction in myelinated axons allows the action potential to leap rapidly between successive nodes of Ranvier, substantially accelerating conduction velocity.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- According to the Punjab Textbook Board (Biology Part II, Chapter 17: Coordination and Control), the velocity of nerve impulses along thick human myelinated fibers reaches 100 to 120 meters per second.
- In contrast, non-myelinated fibers conduct nerve impulses at substantially lower velocities of roughly 1 to 3 meters per second.

Why other options are incorrect:

- Option B:** 130–150 m/s exceeds the physiologically documented conduction range for human motor axons.
- Option C:** 160–180 m/s is an unphysiological velocity not observed in human peripheral nerves.
- Option D:** 190–210 m/s is an extreme value without biological basis in human neural transmission.

Question #54 **Key: (C)**BIOLOGY
01. Cell

One of the following is CORRECT regarding flagella:

CORE CONCEPT & DERIVATION

Eukaryotic flagella and cilia are motile cellular projections whose axoneme core is rooted and nucleated by a modified centriolar structure termed a basal body (kinetosome).

Formula / Rule / Reaction:

Basal Body (9 triplets, 9+0) → Axoneme of Flagellum (9 doublets + 2 singlets, 9+2)

Solution:

- The basal body sits at the base of the flagellum anchored within the cortical cytoplasm, directing the polymerization of axonemal microtubules.
- Thus, flagella originate directly from basal bodies.

Why other options are incorrect:

- Option A:** Flagella are composed of microtubules (tubulin dimers), whereas microfilaments consist of actin.
- Option B:** Flagella do not contain a centriole within their shaft; rather, their root basal body shares structural homology with a centriole.
- Option D:** Flagella are primary cellular organelles of motility that beat dynamically to propel cells through fluids.

Question #55 **Key: (A)**BIOLOGY
12. Nervous Coordination

During the non-conducting state, the neuron membrane is permeable to the efflux of:

CORE CONCEPT & DERIVATION

The resting membrane potential (–70 mV) of an unexcited neuron is determined primarily by the selective permeability of non-gated leakage channels to potassium ions.

Formula / Rule / Reaction:

Resting State: $P_{K^+} \gg P_{Na^+} \Rightarrow$ Efflux of K^+ down chemical gradient

Solution:

- The neuronal membrane at rest is roughly 20 to 100 times more permeable to K^+ than to Na^+ .
- Potassium ions diffuse continuously down their chemical gradient from the cytoplasm to the extracellular fluid through non-gated K^+ leakage channels.

Why other options are incorrect:

- Option B:** Voltage-gated Na^+ channels are closed in the non-conducting state, and resting permeability to Na^+ is minimal.
- Option C:** Resting cell membranes maintain very low calcium conductance; calcium channels open primarily upon presynaptic depolarization.
- Option D:** Although chloride ions can diffuse through specific channels, passive selective efflux establishing resting polarity is dominated by K^+ .

Question #56 **Key: (C)**BIOLOGY
12. Nervous Coordination

Medulla Oblongata is a part of:

CORE CONCEPT & DERIVATION

The vertebrate brain develops into three primary embryonic divisions: forebrain (prosencephalon), midbrain (mesencephalon), and hindbrain (rhombencephalon).

Formula / Rule / Reaction:

Hindbrain (Rhombencephalon) = Cerebellum + Pons + Medulla Oblongata

Solution:

- The hindbrain consists anatomically of the cerebellum, pons, and medulla oblongata.
- The medulla oblongata connects the spinal cord with higher brain centers and regulates autonomic vital functions including heart rate, respiration, and vascular tone.

Why other options are incorrect:

- Option A:** The forebrain consists of the telencephalon (cerebrum) and diencephalon (thalamus, hypothalamus, and epithalamus).
- Option B:** The midbrain contains the tectum, tegmentum, and cerebral peduncles, coordinating auditory and visual reflex responses.
- Option D:** The hippocampus is a component of the limbic system located within the temporal lobe of the forebrain.

Question #57 **Key: (D)**BIOLOGY
10. Homeostasis

Which option is CORRECT about endospore?

CORE CONCEPT & DERIVATION

Bacterial endospores are dehydrated, cryptobiotic survival structures produced by certain Gram-positive bacteria (e.g., *Bacillus* and *Clostridium*) in response to nutrient exhaustion.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Endospores are equipped with a thick keratin-like protein spore coat, a peptidoglycan cortex, and high concentrations of calcium dipicolinate.
- These structural adaptations allow endospores to endure extreme temperatures, desiccation, ionizing radiation, and chemical disinfectants.

Why other options are incorrect:

- **Option A:** Endospores can remain viable in prolonged dormancy lasting decades or centuries.
- **Option B:** The spore core is deeply dehydrated (containing very low water content), which contributes to heat resistance.
- **Option C:** Endospores exhibit zero detectable metabolic activity until germination occurs under favorable conditions.

Question #58 **Key: (C)**BIOLOGY
11. Support & Movement

Which of the following is NOT a bone of upper limb?

CORE CONCEPT & DERIVATION

The human appendicular skeleton is divided into the pectoral girdle with upper limbs, and the pelvic girdle with lower limbs.

Formula / Rule / Reaction:

Upper Limb Bones = Humerus + Radius + Ulna + Carpals + Metacarpals + Phalanges

Solution:

- The femur is the longest, heaviest, and strongest tubular bone in the human body, situated exclusively in the thigh of the lower limb.
- The arm and forearm bones comprise the humerus, radius, and ulna.

Why other options are incorrect:

- **Option A:** The humerus is the single long bone constituting the brachial region (upper arm) of the upper limb.
- **Option B:** The ulna is the medial long bone of the forearm within the upper limb.
- **Option D:** The radius is the lateral long bone of the forearm within the upper limb.

Question #59 **Key: (B)**BIOLOGY
01. Cell

Bacteria divide at an exponential rate during the growth phase:

CORE CONCEPT & DERIVATION

A typical bacterial population growth curve in a closed system exhibits four successive phases: lag phase, log (exponential) phase, stationary phase, and death (decline) phase.

Formula / Rule / Reaction:

$$N_t = N_0 \times 2^n \quad \text{or} \quad \log N_t = \log N_0 + n \log 2$$

Solution:

- During the log (logarithmic or exponential) phase, bacterial cells have adapted to the growth medium and divide at a maximal, constant geometric rate by binary fission.
- The population doubles regularly per generation time, producing a linear upward trajectory on a semi-logarithmic plot.

Why other options are incorrect:

- **Option A:** In the lag phase, bacteria synthesize enzymes, replicate DNA, and increase in volume without an increase in cell number.
- **Option C:** In the stationary phase, nutrient depletion and toxin accumulation cause the rate of cell division to equal the rate of cell death.
- **Option D:** In the decline phase, cell death outpaces new cell formation due to severe environmental exhaustion.

Question #60 **Key: (A)**BIOLOGY
11. Support & Movement

Bone forming cells are:

CORE CONCEPT & DERIVATION

Bone tissue contains three primary specialized cell types: osteoblasts (bone matrix synthesizers), osteocytes (mature matrix maintainers), and osteoclasts (multinucleated matrix resorbers).

Formula / Rule / Reaction:

$$\text{Osteogenic cells} \rightarrow \text{Osteoblasts (bone-forming)} \xrightarrow{\text{Matrix mineralization}} \text{Osteocytes (quiescent)}$$

Solution:

- Osteoblasts are active, cuboidal cells derived from osteoprogenitor mesenchyme.
- They synthesize and secrete osteoid (collagen fibers and ground substance) and promote calcium phosphate precipitation during ossification.

Why other options are incorrect:

- **Option B:** Osteocytes are mature, non-dividing bone cells trapped within lacunae that maintain bone matrix homeostasis.
- **Option C:** Osteoclasts are large, multinucleated monocyte-macrophage lineage cells responsible for enzymatic bone resorption.
- **Option D:** Osteons (Haversian systems) are cylindrical structural units of compact bone tissue, not cells.

Question #61 Key: (A)BIOLOGY
05. Acellular Life

Example of viruses having a polyhedral capsid that is with 252 capsomeres is:

CORE CONCEPT & DERIVATION

Viral capsids exhibit characteristic geometric symmetries with precise capsomere counts. Icosahedral polyhedral capsids are composed of triangular facets meeting at shared vertices.

Formula / Rule / Reaction:

Adenovirus Capsid (252 capsomeres) = 240 hexons (facets/edges) + 12 pentons (vertices)

Solution:

- Adenovirus possesses a naked icosahedral (polyhedral) capsid made up of exactly 252 capsomeres.
- This includes 240 hexon capsomeres forming the 20 triangular triangular faces and 12 penton capsomeres at the vertices from which protein fibers project.

Why other options are incorrect:

- Option B:** Tobacco mosaic virus (TMV) has a helical capsid composed of 2130 identical protein subunits arranged as a hollow cylinder.
- Option C:** Influenza virus is an enveloped, pleomorphic spherical RNA virus lacking a rigid 252-capsomere icosahedral shell.
- Option D:** T-even bacteriophages exhibit binal symmetry, with an icosahedral head attached to a helical contractile tail.

Question #62 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

The chromosomes were first observed by:

CORE CONCEPT & DERIVATION

Chromosomes were originally observed and documented during eukaryotic mitotic cell divisions using synthetic aniline dyes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In 1879, the German anatomist Walther Flemming observed thread-like chromatic structures dividing inside the nuclei of salamander gill cells.
- He coined the term 'chromatin' and described the longitudinal splitting of chromosomes during mitosis.

Why other options are incorrect:

- Option A:** Thomas Hunt Morgan established the chromosomal theory of inheritance using *Drosophila melanogaster* in the early 20th century.
- Option B:** Frederick Griffith discovered bacterial transformation in *Streptococcus pneumoniae* in 1928.
- Option D:** Gregor Mendel deduced the abstract particulate laws of inheritance in 1865 without physical awareness of chromosomes.

Question #63 Key: (C)BIOLOGY
05. Acellular Life

The complete, mature & infectious particle of virus is known as:

CORE CONCEPT & DERIVATION

An intact, fully assembled, extracellular viral unit capable of establishing an infection in a susceptible host is designated a virion.

Formula / Rule / Reaction:

Virion = Nucleic Acid Core (DNA or RNA) + Capsid (+Envelope in enveloped viruses)

Solution:

- The virion represents the complete structural form of a virus when outside the host cell.
- It functions to deliver the viral genome into host target tissues to initiate replication.

Why other options are incorrect:

- Option A:** The viral genome is strictly the nucleic acid component (DNA or RNA), lacking the protective capsid coat.
- Option B:** A capsomere is an individual morphological protein subunit of which the capsid shell is constructed.
- Option D:** The envelope is an optional outer lipid bilayer acquired by certain viruses from host membranes during budding.

Question #64 Key: (D)BIOLOGY
05. Acellular Life

The causative organism of measles is:

CORE CONCEPT & DERIVATION

Measles (rubeola) is an acute, highly contagious viral infection characterized by prodromal fever, cough, coryza, Koplik spots, and a maculopapular exanthem.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The measles virus belongs to the genus Morbillivirus within the family Paramyxoviridae.
- It is an enveloped, negative-sense, single-stranded, non-segmented RNA virus.

Why other options are incorrect:

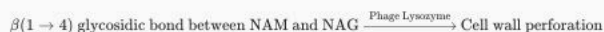
- Option A:** Poxviruses (Poxviridae) are large double-stranded DNA viruses causing smallpox and molluscum contagiosum.
- Option B:** Papovaviruses (Papovaviridae, now Papillomaviridae/Polyomaviridae) cause warts and cervical dysplasia.
- Option C:** Picornaviruses (Picornaviridae) are small positive-sense RNA viruses causing poliomyelitis, hepatitis A, and the common cold (rhinovirus).

Question #65 Key: (B)BIOLOGY
05. Acellular Life

In the life cycle of a bacteriophage, the lysozymes are required in which of the following step...

CORE CONCEPT & DERIVATION

During the penetration stage of a T-even bacteriophage, the phage tail releases an enzyme that locally hydrolyzes the bacterial peptidoglycan wall.

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

- Following adsorption, the phage tail sheath contracts, thrusting the hollow central tube through the outer bacterial envelope.
- Phage lysozyme enzymatically digests a localized opening in the rigid murein layer, allowing penetration and subsequent genome entry.

Why other options are incorrect:

- Option A:** Genome injection is driven by the physical expulsion of pressurized DNA from the capsid head through the core tube into the cytoplasm.
- Option C:** Phage replication relies on host and viral DNA polymerases, helicases, and ribosomes inside the bacterial cytoplasm.
- Option D:** Adsorption is a purely electrostatic, non-enzymatic recognition event between phage tail fibers and host surface receptors.

Question #66 Key: (A)BIOLOGY
05. Acellular Life

_____ is transmitted through infected blood and hypodermic syringes.

CORE CONCEPT & DERIVATION

Pathogens transmitted parenterally require direct inoculation into the vascular system or mucous membranes via contaminated blood or needles.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Human Immunodeficiency Virus (HIV) is an enveloped retrovirus transmitted efficiently through contaminated blood, blood products, unsterilized hypodermic syringes, and vertical transmission.
- Intravenous drug users sharing hypodermic needles represent a major high-risk group for HIV acquisition.

Why other options are incorrect:

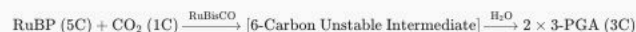
- Option B:** Influenza virus is an airborne respiratory pathogen transmitted via aerosols and respiratory droplets.
- Option C:** Morbillivirus (measles) spreads via airborne respiratory droplets through coughing and sneezing.
- Option D:** Vibrio cholerae is an enteric bacterium transmitted via the fecal-oral route through contaminated drinking water or food.

Question #67 Key: (C)BIOLOGY
04. Bioenergetics

In the Calvin cycle, [Formula] reacts with RuBP to produce _____.

CORE CONCEPT & DERIVATION

Carbon fixation in the stroma is catalyzed by RuBisCO, which carboxylates ribulose-1,5-bisphosphate to form a transient, highly unstable 6-carbon intermediate.

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

- Carbon dioxide (1C) is condensed with ribulose bisphosphate (5C) by RuBisCO.
- The immediate reaction product is an unstable enzyme-bound 6-carbon compound that hydrolyzes spontaneously into two molecules of 3-phosphoglycerate (3-PGA).
- Therefore, the immediate chemical species produced upon carboxylation is the 6-carbon unstable intermediate.

Why other options are incorrect:

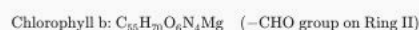
- Option A:** 3-PGA is the first stable chemical product formed after the immediate cleavage of the 6-carbon intermediate.
- Option B:** Glyceraldehyde-3-phosphate (G3P) is generated subsequent to the reduction of 1,3-bisphosphoglycerate by NADPH.
- Option D:** 1,3-bisphosphoglycerate is formed when 3-PGA is phosphorylated by ATP in the second phase of the Calvin cycle.

Question #68 Key: (C)BIOLOGY
04. Bioenergetics

Which option is correct about a chlorophyll molecule?

CORE CONCEPT & DERIVATION

Chlorophyll consists of a hydrophilic porphyrin head (four pyrrole rings coordinated around a central magnesium atom) and a hydrophobic phytol hydrocarbon tail.

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

- In chlorophyll a, a methyl group ($-\text{CH}_3$) is bonded at carbon-3 of the second pyrrole ring (Ring II).
- In chlorophyll b, this methyl group is replaced by a formyl/aldehyde group ($-\text{CHO}$).
- Note on Board Key:** The official UHS 2024 key designated Option C as the correct statement for chlorophyll a.

Why other options are incorrect:

- Option A:** $\text{C}_{55}\text{H}_{70}\text{O}_6\text{N}_4\text{Mg}$ is the formula for chlorophyll b, not chlorophyll a.
- Option B:** The porphyrin head has a divalent magnesium ion (Mg^{2+}) coordinated in the center, surrounded by four nitrogens.
- Option D:** An aldehyde group on the second pyrrole ring is characteristic exclusively of chlorophyll b.

Question #69 Key: (D)CHEMISTRY
17. Aldehydes & Ketones

Which of the following alcohol can give a Iodoform reaction?

CORE CONCEPT & DERIVATION

The iodoform (triiodomethane) haloform reaction requires alcohols possessing the $\text{CH}_3\text{-CH(OH)-}$ structural group, which are readily oxidized to methyl ketones or ethanal.

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

- Ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) is oxidized by hypoiodite to acetaldehyde (CH_3CHO), which contains the necessary $\text{CH}_3\text{-C=O}$ group.
- Subsequent halogenation and basic cleavage yield a pale yellow precipitate of iodoform (CHI_3).
- Ethanol is the only primary alcohol capable of yielding a positive iodoform test.

Why other options are incorrect:

- Option A:** Methanol (CH_3OH) contains only one carbon and cannot form a methyl carbonyl intermediate.
- Option B:** 1-Butanol is a primary alcohol with the formula $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$, oxidizing to butanal, which lacks a methyl carbonyl group.
- Option C:** 1-Propanol ($\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$) oxidizes to propanal, lacking the α -methyl group required for the haloform reaction.

Question #70 Key: (B)CHEMISTRY
08. Reaction Kinetics

Which of the following is the correct Arrhenius equation?

CORE CONCEPT & DERIVATION

The Arrhenius equation quantitatively relates the rate constant of a chemical reaction to absolute temperature and the activation energy barrier.

Formula / Rule / Reaction:

$$k = Ae^{-\frac{E_a}{RT}}$$

where k = rate constant, A = pre-exponential factor, E_a = activation energy, R = gas constant, T = absolute temperature

Solution:

- The term $e^{-E_a/RT}$ represents the Boltzmann fraction of colliding molecules with kinetic energy equal to or greater than the activation energy E_a .
- The universal gas constant R is the scaling parameter, making Option B the correct mathematical formulation.

Why other options are incorrect:

- Option A:** Q is not the universal gas constant; it denotes reaction quotient or heat energy.
- Option C:** S represents entropy, not the gas constant in the Arrhenius kinetic expression.
- Option D:** U represents internal energy, not the universal gas constant.

Question #71 Key: (C)CHEMISTRY
02. Atomic Structure

Which of the following electronic configurations is correct for carbon?

CORE CONCEPT & DERIVATION

The ground-state electronic configuration of an atom follows the Aufbau principle, Hund's rule, and the Pauli exclusion principle based on its atomic number Z .

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

- Subshells fill in order of increasing $n + l$ energy: $1s \rightarrow 2s \rightarrow 2p$.
- Allocating six electrons: 2 in $1s$, 2 in $2s$, and the remaining 2 in $2p$.
- The ground-state configuration is $1s^2 2s^2 2p^2$ (or $1s^2 2s^2 2p_x^1 2p_y^1 2p_z^0$).

Why other options are incorrect:

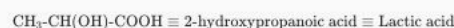
- Option A:** $1s^2 2s^2 2p^3$ has 7 electrons, representing nitrogen ($Z = 7$).
- Option B:** $1s^2 2s^2 2p^4$ has 8 electrons, representing oxygen ($Z = 8$).
- Option D:** $1s^2 2s^2 2p^1$ has 5 electrons, representing boron ($Z = 5$).

Question #72 Key: (B)CHEMISTRY
18. Carboxylic Acids

Common name of 2-hydroxypropanoic acid is:

CORE CONCEPT & DERIVATION

Alpha-hydroxy carboxylic acids have historic trivial names derived from their natural biological sources.

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

- The compound $\text{CH}_3\text{-CH(OH)-COOH}$ contains a 3-carbon propanoic acid chain with a hydroxyl substituent at carbon-2.
- Its historic common name is lactic acid (originally isolated from sour milk).

Why other options are incorrect:

- Option A:** Tartaric acid is 2,3-dihydroxybutanedioic acid, found in grapes.
- Option C:** Phthalic acid is benzene-1,2-dicarboxylic acid, an aromatic dicarboxylic acid.
- Option D:** Formic acid is methanoic acid (HCOOH), the simplest single-carbon carboxylic acid.

Question #73 Key: (C)

CHEMISTRY
07. Equilibrium

In endothermic reaction, the heat content of the:

CORE CONCEPT & DERIVATION

Enthalpy of reaction (ΔH) reflects the difference between the heat content (enthalpy) of the products (H_p) and that of the reactants (H_r).

Formula / Rule / Reaction:

$$\Delta H = H_p - H_r > 0 \implies H_p > H_r$$

Solution:

- In an endothermic process, the system absorbs heat from its surroundings.
- Because enthalpy is added into chemical bonds, the enthalpy of products (H_p) is greater than the enthalpy of reactants (H_r).

Why other options are incorrect:

- Option A:** Equal heat content would mean $\Delta H = 0$, indicating a thermoneutral reaction.
- Option B:** When the heat content of reactants exceeds that of products, $\Delta H < 0$, which defines an exothermic reaction.
- Option D:** Chemical transformations almost always involve bond rearrangements that alter heat content.

Question #74 Key: (D)

CHEMISTRY
04. Gases

Intermolecular forces between molecules of ideal gas are:

CORE CONCEPT & DERIVATION

The Kinetic Molecular Theory of Gases establishes fundamental postulates describing the behavior of hypothetical ideal gas particles.

Formula / Rule / Reaction:

$$F_{\text{attraction}} = 0 \quad \text{and} \quad F_{\text{repulsion}} = 0 \quad (\text{for an ideal gas})$$

Solution:

- One primary postulate of the kinetic theory states that gas molecules exert neither attractive nor repulsive forces on one another.
- Therefore, intermolecular forces in an ideal gas are completely absent.

Why other options are incorrect:

- Option A:** Strong intermolecular forces exist in liquids and solids, causing significant deviation from gas ideality.
- Option B:** Moderate intermolecular forces lead to non-ideal gas behavior.
- Option C:** Weak van der Waals forces exist in real gases; in an ideal gas, they are postulated to be zero.

Question #75 Key: (B)

CHEMISTRY
16. Alcohols & Phenols

Which of the following is correct regarding phenol?

CORE CONCEPT & DERIVATION

The relative acidity of organic compounds depends on the resonance stabilization and charge delocalization in their conjugate base anions.

Formula / Rule / Reaction:

Order of Acidity: Carboxylic Acid ($pK_a \approx 4-5$) > Phenol ($pK_a \approx 10$) > Water ($pK_a \approx 14$) > Ethanol

Solution:

- The carboxylate anion (RCOO^-) stabilizes negative charge over two electronegative oxygen atoms.
- The phenoxide ion ($\text{C}_6\text{H}_5\text{O}^-$) delocalizes charge into the less electronegative carbon atoms of the aromatic ring.
- Consequently, phenol is a weaker acid than carboxylic acid.

Why other options are incorrect:

- Option A:** Phenol ($pK_a = 9.95$) is about four orders of magnitude more acidic than water ($pK_a = 14$).
- Option C:** Phenol is more acidic than water because phenoxide is resonance-stabilized, whereas hydroxide is not.
- Option D:** Phenol is far more acidic than ethanol, as ethoxide cannot delocalize its negative charge.

Question #76 Key: (B)

CHEMISTRY
04. Gases

The correct ideal gas equation is:

CORE CONCEPT & DERIVATION

The ideal gas equation combines Boyle's law, Charles's law, and Avogadro's law into a unified equation of state.

Formula / Rule / Reaction:

$$pV = nRT$$

where p = pressure, V = volume, n = moles, R = gas constant, T = absolute temperature

Solution:

- Boyle's Law: $V \propto \frac{1}{p}$
- Charles's Law: $V \propto T$
- Avogadro's Law: $V \propto n$
- Combining these gives $V \propto \frac{1}{p} T n$, which simplifies to $pV = nRT$.

Why other options are incorrect:

- Option A:** q represents heat, not pressure.
- Option C:** g represents mass in grams or acceleration due to gravity.
- Option D:** y is an arbitrary variable without physical meaning in the gas laws.

Question #77 Key: (C)

CHEMISTRY
04. Gases

The real gases show deviation from ideal behaviour at:

CORE CONCEPT & DERIVATION

Real gases deviate from ideal behavior when intermolecular attractions become significant and the physical volume of the gas particles is no longer negligible compared to the total container volume.

Formula / Rule / Reaction:

$$\left(p + \frac{an^2}{V^2}\right)(V - nb) = nRT \quad (\text{van der Waals equation})$$

Solution:

- At low temperatures, average molecular kinetic energy decreases, enabling intermolecular attractive forces to pull molecules together.
- At high pressures, molecules are compressed into small volumes, making their finite physical volume significant.
- Thus, real gases show maximal deviation from ideality at low temperature and high pressure.

Why other options are incorrect:

- Option A:** Low pressure promotes ideal behavior because molecules are far apart.
- Option B:** High temperature provides high kinetic energy that overcomes attractive forces, reducing deviation.
- Option D:** High temperature and low pressure are the conditions where real gases behave most ideally.

Question #78 Key: (B)

CHEMISTRY
05. Liquids

To boil water at 110 °C, external pressure should be:

CORE CONCEPT & DERIVATION

A liquid boils when its saturated vapor pressure equals the external atmospheric pressure. Elevating the boiling point above its standard value requires raising the external pressure above 1 atm (760 torr).

Formula / Rule / Reaction:

$$\ln\left(\frac{p_2}{p_1}\right) = -\frac{\Delta H_{\text{vap}}}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

At 100 °C, $p = 760$ torr; At 110 °C, $p_{\text{vap}} \approx 1074.6$ torr

Solution:

- At standard pressure (760 torr), water boils at 100 °C.
- At 110 °C, the vapor pressure of water rises to roughly 1075 torr (1.41 atm).
- To make water boil at 110 °C, external pressure must equal this vapor pressure, which falls in the 760 to 1200 torr range.

Why other options are incorrect:

- Option A:** Pressures below 760 torr lower the boiling point of water below 100 °C (e.g., at high altitudes).
- Option C:** 665–670 torr corresponds to a boiling point around 96–97 °C.
- Option D:** 660–700 torr lowers the boiling temperature below 100 °C.

Question #79 Key: (A)

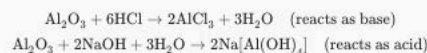
CHEMISTRY
11. S & P Block Elements

Which of the following is not basic in nature?

CORE CONCEPT & DERIVATION

Metal oxides across Period 3 transition from strongly basic to amphoteric to acidic as metallic character decreases and metal–oxygen bond covalency increases.

Formula / Rule / Reaction:



Solution:

- Aluminum oxide (Al_2O_3) is an amphoteric oxide that reacts with both acids and strong bases.
- In contrast, Na_2O , K_2O , and MgO are purely basic metal oxides.

Why other options are incorrect:

- Option B:** Magnesium oxide (MgO) is a basic oxide that reacts with acids to produce magnesium salts and water.
- Option C:** Potassium oxide (K_2O) is a strongly basic alkali metal oxide that dissolves in water to form KOH .
- Option D:** Sodium oxide (Na_2O) is a strongly basic ionic oxide forming NaOH in aqueous solution.

Question #80 Key: (B)

CHEMISTRY
11. S & P Block Elements

The solubility of sulphates of alkaline earth metals generally:

CORE CONCEPT & DERIVATION

The solubility of ionic salts depends on the balance between lattice energy (ΔH_{latt}) and hydration enthalpy (ΔH_{hyd}).

Formula / Rule / Reaction:

$$\Delta H_{\text{solution}} = \Delta H_{\text{latt}} - \Delta H_{\text{hyd}}$$

Solution:

- The sulfate anion (SO_4^{2-}) is very large, so the lattice energy of Group II sulfates remains relatively constant down the group.
- However, as the cation radius increases from Be^{2+} to Ba^{2+} , the hydration enthalpy decreases sharply.
- Because hydration energy falls faster than lattice energy, dissolving becomes increasingly endothermic, so sulfate solubility decreases down Group II ($\text{BeSO}_4 > \text{MgSO}_4 > \text{CaSO}_4 > \text{SrSO}_4 > \text{BaSO}_4$).

Why other options are incorrect:

- Option A:** Hydroxides of Group II show increasing solubility down the group, whereas sulfates show the opposite trend.
- Option C:** Sulfate solubility decreases monotonically down Group II without reversing.
- Option D:** There is a marked experimental decrease in solubility from freely soluble MgSO_4 to insoluble BaSO_4 .

Question #81 Key: (C)

CHEMISTRY
01. Stoichiometry

The atomic masses of elements depend upon:

CORE CONCEPT & DERIVATION

The relative atomic mass of an element listed on the periodic table is the weighted average mass of all its naturally occurring isotopes relative to carbon-12.

Formula / Rule / Reaction:

$$\text{Average Atomic Mass} = \sum_{i=1}^n \frac{(\text{Isotopic Mass}_i \times \% \text{ Abundance}_i)}{100}$$

Solution:

- Most elements occur as mixtures of isotopes having identical atomic numbers but different neutron counts and masses.
- Therefore, fractional atomic mass is determined by both the individual mass of each isotope and its natural percentage abundance.

Why other options are incorrect:

- Option A:** Atomic number denotes the number of nuclear protons, which defines the chemical element but not its isotopic average mass.
- Option B:** The number of electrons equals the number of protons in a neutral atom, but electron mass is negligible compared to nucleon mass.
- Option D:** Option C is the correct physical definition.

Question #82 Key: (D)

CHEMISTRY
05. Liquids

Which one of the following DO NOT have a tendency to form hydrogen bonding?

CORE CONCEPT & DERIVATION

Hydrogen bonding requires a hydrogen atom covalently bonded to a small, highly electronegative atom with lone pairs, specifically nitrogen, oxygen, or fluorine.

Formula / Rule / Reaction:

H-bond Donor requirement: X-H (where X = N, O, or F)

Solution:

- Hydrocarbons contain exclusively carbon and hydrogen atoms.
- The electronegativity difference between carbon (2.55) and hydrogen (2.20) is minimal, so C-H bonds lack the polar dipole necessary to engage in hydrogen bonding.

Why other options are incorrect:

- Option A:** Ammonia (NH₃) forms intermolecular hydrogen bonds through its electronegative nitrogen atom and lone pair.
- Option B:** Ethyl alcohol (CH₃CH₂OH) forms strong hydrogen bonds via its polar hydroxyl (–OH) group.
- Option C:** Carboxylic acids form strong hydrogen-bonded dimers in both liquid state and nonpolar solvents.

Question #83 Key: (C)

CHEMISTRY
14. Hydrocarbons

Which of the following is an example of substituent group which release electrons to benzene ring...

CORE CONCEPT & DERIVATION

Substituents on a benzene ring are classified as electron-donating (activating) or electron-withdrawing (deactivating) through resonance and inductive effects.

Formula / Rule / Reaction:

Resonance Electron Donation: C₆H₅-NH₂ ↔ ortho/para delocalized carbanion intermediates

Solution:

- The amino group (–NH₂) possesses a lone pair of electrons on the nitrogen atom adjacent to the aromatic π-system.
- By +M (positive mesomeric) resonance, nitrogen donates electron density into the ring, strongly activating it toward electrophilic aromatic substitution.

Why other options are incorrect:

- Option A:** The cyano group (–C≡N) withdraws electrons from the ring via both inductive (–I) and resonance (–M) effects.
- Option B:** The quaternary ammonium group (–NR₄⁺) carries a positive charge and is strongly electron-withdrawing through its –I effect.
- Option D:** The nitro group (–NO₂) is a powerful electron-withdrawing group via strong –M and –I effects.

Question #84 Key: (C)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Which type of isomerism is displayed by compounds having the same structural formula but differ...

CORE CONCEPT & DERIVATION

Geometric (cis-trans) isomerism occurs when restricted rotation around a carbon-carbon double bond or cyclic ring causes substituents to occupy different spatial arrangements on opposite sides of the bond.

Formula / Rule / Reaction:

cis: similar groups on same side; trans: similar groups on opposite sides

Solution:

- Compounds with identical connectivity but different arrangements of atoms across a rigid carbon bond display geometric isomerism.
- Note on Board Key:** The official UHS 2024 paper keyed Option C for this textbook question.

Why other options are incorrect:

- Option A:** Chain isomerism arises from different branching arrangements of the carbon skeleton.
- Option B:** Metamerism is caused by unequal distribution of carbon atoms on either side of a polyvalent functional group (e.g., in ethers).
- Option D:** Tautomerism involves a dynamic equilibrium between two structural isomers resulting from proton migration (e.g., keto-enol).

Question #85 Key: (D)CHEMISTRY
12. Transition Elements

Which of the following is NOT an Alloy?

CORE CONCEPT & DERIVATION

An alloy is a solid solution or homogeneous metallic mixture composed of two or more elements, with at least one being a metal.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Graphite is a pure elemental allotrope of carbon arranged in planar hexagonal sheets of sp^2 -hybridized atoms.
- Because it is an allotrope of a non-metal rather than a metallic mixture, graphite is not an alloy.

Why other options are incorrect:

- Option A:** Steel is an interstitial alloy composed predominantly of iron with carbon (0.2 to 2.1%).
- Option B:** Brass is a substitutional alloy composed of copper and zinc.
- Option C:** Bronze is a metallic alloy composed primarily of copper and tin.

Question #86 Key: (C)CHEMISTRY
12. Transition Elements

Electronic configuration of chromium (proton number 24) is:

CORE CONCEPT & DERIVATION

Half-filled and completely filled subshells possess extra stability due to symmetrical electron distribution and higher exchange energy.

Formula / Rule / Reaction:

Expected: $[\text{Ar}] 3d^4 4s^2$ $\xrightarrow{\text{Exchange stabilization}}$ Actual: $[\text{Ar}] 3d^5 4s^1$

Solution:

- Promoting one electron from the $4s$ orbital into the $3d$ subshell converts chromium into a half-filled $3d^5 4s^1$ configuration.
- This symmetrical half-filled state maximizes exchange energy, stabilizing the atom relative to the expected $3d^4 4s^2$ state.

Why other options are incorrect:

- Option A:** $[\text{Ar}] 3d^4 4s^2$ is the unshifted Aufbau expectation that does not account for exchange stabilization.
- Option B:** $[\text{Ar}] 3d^2 4s^2$ represents titanium ($Z = 22$), with 22 total electrons.
- Option D:** $[\text{Ar}] 3d^5 4s^2$ contains 25 electrons, which is the configuration for manganese ($Z = 25$).

Question #87 Key: (A)CHEMISTRY
10. Electrochemistry

Which step is irrelevant concerning the balancing of redox equations by the oxidation number method...

CORE CONCEPT & DERIVATION

Redox reactions can be balanced using either the oxidation number method or the ion-electron (half-reaction) method. Splitting an equation into separate oxidation and reduction half-reactions is the defining step of the half-reaction method, not the oxidation number method.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In the oxidation number method, you assign oxidation numbers directly across the whole skeletal equation, identify which atoms undergo oxidation state changes, and balance the net increase and decrease with suitable stoichiometric coefficients.
- Separating into two half-reactions belongs specifically to the ion-electron method.

Why other options are incorrect:

- Option B:** Assigning oxidation numbers to all atoms is the essential first step of the oxidation number method.
- Option C:** Identifying the elements undergoing changes in oxidation state is necessary to find the oxidized and reduced species.
- Option D:** Equalizing the total increase in oxidation number with the total decrease in oxidation number is the central balancing step.

Question #88 Key: (C)CHEMISTRY
10. Electrochemistry

Which of the following is NOT a correct feature of electrolytic cells?

CORE CONCEPT & DERIVATION

An electrolytic cell uses electrical energy from an external power supply to drive a non-spontaneous redox reaction. It requires direct current (DC) to sustain directional ion migration.

Formula / Rule / Reaction:

Cathode: Reduction (gain of e^-) | Anode: Oxidation (loss of e^-) | Power Source: Direct Current

Solution:

- An electrolytic cell must be connected to a direct current (DC) source like a battery so that the anode remains constantly positive and the cathode remains constantly negative.
- An alternating current (AC) source would repeatedly reverse electrode polarity, preventing net directional electrolysis.

Why other options are incorrect:

- Option A:** Reduction occurs at the cathode in all electrochemical cells (both electrolytic and galvanic).
- Option B:** Oxidation occurs at the anode in all electrochemical cells.
- Option D:** Conversion of electrical energy into chemical change is an electrochemical reaction.

Question #89 Key: (C)

CHEMISTRY
03. Chemical Bonding

Which of the following has a coordinate bond?

CORE CONCEPT & DERIVATION

A coordinate covalent (dative) bond forms when both shared electrons in a covalent bond are donated by one atom (the Lewis base) to an electron-deficient atom (the Lewis acid).

Formula / Rule / Reaction:



Solution:

- In NH_3 , nitrogen has a lone pair of electrons.
- In BF_3 , boron has an incomplete octet with only six valence electrons and an empty $2p$ orbital.
- Nitrogen donates its lone pair into the empty boron orbital, forming a coordinate covalent bond.

Why other options are incorrect:

- Option A:** Sodium chloride (NaCl) is bonded purely by ionic electrostatic attraction between Na^+ and Cl^- .
- Option B:** Calcium oxide (CaO) is an ionic lattice of Ca^{2+} and O^{2-} ions.
- Option D:** Water (H_2O) contains two polar, single covalent bonds with mutual electron sharing.

Question #90 Key: (D)

CHEMISTRY
03. Chemical Bonding

Which of the following is NOT a feature of Valence Shell Electron Pair Repulsion theory?

CORE CONCEPT & DERIVATION

Valence Shell Electron Pair Repulsion (VSEPR) theory states that both bonding pairs and lone pairs of electrons in the valence shell arrange themselves around the central atom to minimize electrostatic repulsions.

Formula / Rule / Reaction:

$$\text{Steric Number} = (\text{Number of bonded atoms}) + (\text{Number of lone pairs})$$

Solution:

- Both bonding pairs and lone pairs determine the electron pair geometry and the final molecular shape.
- Therefore, stating that only lone pairs participate in determining molecular geometry is incorrect.

Why other options are incorrect:

- Option A:** Determining the spatial geometric shapes of polyatomic molecules is the primary purpose of VSEPR theory.
- Option B:** Mutual electrostatic repulsion between electron pairs is the central physical postulate of VSEPR theory.
- Option C:** Three-dimensional molecular geometry derived from VSEPR helps explain drug-receptor binding interactions.

Question #91 Key: (B)

CHEMISTRY
03. Chemical Bonding

Which of the following has smallest atomic radius:

CORE CONCEPT & DERIVATION

Across a period from left to right in the periodic table, effective nuclear charge (Z_{eff}) increases while electrons enter the same principal valence shell, pulling electrons closer to the nucleus and decreasing atomic radius.

Formula / Rule / Reaction:

$$\text{Period 3 Trend: Na (186 pm)} > \text{Mg (160 pm)} > \text{P (110 pm)} > \text{S (102 pm)}$$

Solution:

- Sodium, magnesium, phosphorus, and sulfur all belong to Period 3.
- Sulfur has the highest atomic number ($Z = 16$) among them, giving it the highest effective nuclear charge and smallest atomic radius.

Why other options are incorrect:

- Option A:** Magnesium (Group 2) has an atomic radius of approximately 160 pm, larger than sulfur.
- Option C:** Phosphorus (Group 15) lies to the left of sulfur and has an atomic radius of roughly 110 pm.
- Option D:** Sodium (Group 1) is at the far left of Period 3 and has the largest radius (186 pm).

Question #92 Key: (D)

CHEMISTRY
11. S & P Block Elements

The difference of lithium from the other alkali metals is mainly because of:

CORE CONCEPT & DERIVATION

The anomalous behavior of the first member of any periodic group is due to its exceptionally small atomic/ionic size and high polarizing power (charge density).

Formula / Rule / Reaction:

$$\text{Charge Density} = \frac{\text{Ionic Charge}}{\text{Ionic Volume}} \propto \frac{+1}{r^3}$$

Solution:

- Lithium has the smallest atomic and ionic radius ($\text{Li}^+ = 76 \text{ pm}$) in Group 1.
- Its +1 charge concentrated over a small volume produces a high charge density and strong polarizing power.
- This gives lithium compounds significant covalent character and explains its diagonal relationship with magnesium.

Why other options are incorrect:

- Option A:** Lithium has the smallest radius in Group 1, not a large radius, and its charge density is high.
- Option B:** Lithium's small radius produces a high charge density, not a low one.
- Option C:** Lithium does not have a large radius; large radii with low charge density characterize heavier alkali metals like cesium.

Question #93 Key: (C)

CHEMISTRY
05. Liquids

Boiling point of a liquid is a temperature at which:

CORE CONCEPT & DERIVATION

The boiling point is the temperature at which the saturated vapor pressure of a liquid equals the external pressure exerted on its surface.

Formula / Rule / Reaction:

$$P_{\text{vapor}}(T_{\text{boiling}}) = P_{\text{external}}$$

Solution:

- When vapor pressure reaches external atmospheric pressure, vapor bubbles can form throughout the bulk of the liquid without collapsing.
- This condition marks the boiling point of the liquid.

Why other options are incorrect:

- Option A:** Surface tension has units of force per unit length ($\text{N} \cdot \text{m}^{-1}$) and cannot be equated with pressure.
- Option B:** Viscosity is resistance to fluid flow and does not define the phase boundary for boiling.
- Option D:** Viscosity and pressure have different physical dimensions and units.

Question #94 Key: (D)

CHEMISTRY
12. Transition Elements

Which of the following is NOT a property of transition elements?

CORE CONCEPT & DERIVATION

Transition elements have partially filled d -orbitals. Crystal field splitting of these d -orbitals allows electrons to undergo $d-d$ transitions by absorbing wavelengths in the visible spectrum, making their compounds colored.

Formula / Rule / Reaction:

$$\Delta E = h\nu = \frac{hc}{\lambda} \quad (d-d \text{ electronic transition})$$

Solution:

- Transition metals typically form vividly colored complexes due to electronic transitions between split d -orbitals.
- Therefore, the statement that their ions and compounds are colorless is incorrect.

Why other options are incorrect:

- Option A:** Strong metallic bonding involving both ns and $(n-1)d$ electrons gives transition elements high melting and boiling points.
- Option B:** Delocalized outer valence electrons make transition metals good electrical conductors.
- Option C:** Strong interatomic cohesion makes most transition metals hard and durable.

Question #95 Key: (B)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

1-Butene and two Butene are showing which type of isomerism?

CORE CONCEPT & DERIVATION

Position isomerism occurs when constitutional isomers have the same carbon skeleton and functional group, but the functional group is located at different positions along the chain.

Formula / Rule / Reaction:



Solution:

- Both 1-butene and 2-butene share the molecular formula C_4H_8 and the same four-carbon unbranched carbon chain.
- They differ only in whether the alkene double bond begins at carbon-1 or carbon-2.
- This represents position isomerism.

Why other options are incorrect:

- Option A:** Functional group isomers have different functional groups (e.g., an alkene and a cycloalkane).
- Option C:** Metamerism is caused by unequal distribution of carbons attached to a central polyvalent heteroatom.
- Option D:** Chain isomers differ in the branching of their carbon backbone (e.g., butane and 2-methylpropane).

Question #96 Key: (A)

CHEMISTRY
06. Solids

Whenever the crystalline solids are broken they do so along definite planes known as:

CORE CONCEPT & DERIVATION

Crystalline solids have an orderly, periodic internal arrangement of particles. When mechanical stress is applied, crystals split along planes with weaker interatomic forces, termed cleavage planes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Cleavage planes correspond to crystallographic lattice directions where atomic packing density is high and bonding between adjacent layers is comparatively weak.
- Splitting along these orientations produces clean, smooth, characteristic flat surfaces.

Why other options are incorrect:

- Option B:** Refractory refers to heat-resistant materials (e.g., firebricks) that withstand high temperatures, not cleavage planes.
- Option C:** The sagittal plane is an anatomical orientation plane dividing a body into left and right sections.
- Option D:** The coronal plane is an anatomical plane dividing a body into anterior and posterior parts.

Question #97 Key: (A)CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Homocyclic organic compounds are subdivided into two types, namely:

CORE CONCEPT & DERIVATION

Homocyclic (carbocyclic) compounds contain rings composed solely of carbon atoms. In the Punjab Textbook Board classification, homocyclic compounds are divided into alicyclic and aromatic hydrocarbons.

Formula / Rule / Reaction:

Homocyclic Compounds = Alicyclic (aliphatic cyclic) + Aromatic (benzene ring containing)

Solution:

- Alicyclic compounds are non-aromatic carbocycles such as cyclopropane, cyclopentane, or cyclohexene.
- Aromatic compounds contain at least one benzene-like conjugated ring satisfying Huckel's rule.

Why other options are incorrect:

- **Option B:** Alkenes and alkynes are open-chain unsaturated aliphatic hydrocarbons.
- **Option C:** Non-aromatic includes open-chain aliphatic molecules, so it is not a direct subcategory of homocycles.
- **Option D:** Saturated and unsaturated describe carbon-carbon bond orders across both open-chain and cyclic compounds.

Question #98 Key: (C)CHEMISTRY
06. Solids

One of the following is NOT an example of amorphous solids?

CORE CONCEPT & DERIVATION

Solids are categorized as crystalline or amorphous. Crystalline solids possess long-range periodic order with sharp melting points, whereas amorphous solids lack regular internal geometric order.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Solid glucose is a crystalline molecular solid whose molecules are arranged in a periodic lattice held together by directional hydrogen bonds.
- Because glucose is crystalline, it is not an amorphous solid.

Why other options are incorrect:

- **Option A:** Plastics are disordered polymer chains that soften over a temperature range, representing amorphous solids.
- **Option B:** Glass is a supercooled liquid lacking long-range three-dimensional periodicity, a classic amorphous solid.
- **Option D:** Rubber consists of tangled elastomer polymers, making it an amorphous solid.

Question #99 Key: (B)CHEMISTRY
06. Solids

In graphite the carbon atoms are arranged in which of the following structure?

CORE CONCEPT & DERIVATIONGraphite is an allotrope of carbon where each carbon atom is sp^2 -hybridized, forming planar sheets of fused six-membered rings.**Formula / Rule / Reaction:**Bond angle in planar ring = $120^\circ \implies$ Hexagonal planar rings stacked in layers**Solution:**

- Each carbon bonds covalently to three neighboring carbons in a plane, creating planar hexagonal network layers.
- These layers are held together by weak van der Waals forces, forming a hexagonal crystal system.

Why other options are incorrect:

- **Option A:** Rhombic geometry is found in orthorhombic crystals such as rhombic sulfur, not graphite.
- **Option C:** Tetragonal systems have two equal axes and one different axis at 90° -degree angles, seen in white tin or rutile.
- **Option D:** Trigonal describes the local bonding geometry around individual sp^2 carbons, but the overall crystalline network is hexagonal.

Question #100 Key: (B)CHEMISTRY
07. Equilibrium

The principle that states that if a stress is applied to a system at equilibrium, the system nu...

CORE CONCEPT & DERIVATION

Chemical equilibrium is dynamic. Henri Le Chatelier formulated the fundamental principle describing how systems in equilibrium respond to external disturbances.

Formula / Rule / Reaction:External Stress ($\Delta T, \Delta P, \Delta C$) $\implies$ Equilibrium shifts in direction that opposes change**Solution:**

- Le Chatelier's principle states that if an external stress (change in concentration, temperature, or pressure) is applied to a chemical system at equilibrium, the position of equilibrium shifts in the direction that counteracts and minimizes the effect of that stress.

Why other options are incorrect:

- **Option A:** Fritz Haber developed the industrial process for synthesizing ammonia from nitrogen and hydrogen.
- **Option C:** Boyle's law describes the inverse relationship between the pressure and volume of a fixed mass of gas at constant temperature.
- **Option D:** Charles's law describes the direct proportionality between gas volume and absolute temperature at constant pressure.

Question #101 Key: (A)

CHEMISTRY
14. Hydrocarbons

In Friedel Craft acylation an acyl group is introduced in benzene ring in the presence of catal...

CORE CONCEPT & DERIVATION

Friedel-Crafts acylation involves electrophilic aromatic substitution where an acyl group (R-C=O) is transferred to a benzene ring using an anhydrous Lewis acid catalyst.

Formula / Rule / Reaction:



Solution:

- Anhydrous aluminum chloride (AlCl₃) acts as a strong Lewis acid by coordinating with the chlorine atom of the acyl chloride.
- This generates a resonance-stabilized acylium cation ($[\text{R-C} \equiv \text{O}^+ \leftrightarrow \text{R-C}^+ = \text{O}]$), which acts as the electrophile attacking the benzene ring.

Why other options are incorrect:

- **Option B:** Concentrated H₂SO₄ is the protonating and dehydrating catalyst used in nitration and sulfonation, not Friedel-Crafts acylation.
- **Option C:** Sunlight promotes free-radical side-chain halogenation of alkylbenzenes, not electrophilic acylation.
- **Option D:** Vanadium pentoxide (V₂O₅) is an industrial heterogeneous oxidation catalyst used in the Contact process and benzene oxidation to maleic anhydride.

Question #102 Key: (A)

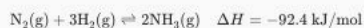
CHEMISTRY
07. Equilibrium

Identify the CORRECT option required for the maximum yield of ammonia by Haber's Process:

CORE CONCEPT & DERIVATION

The synthesis of ammonia from nitrogen and hydrogen is a reversible, exothermic reaction that proceeds with a decrease in the number of moles of gas.

Formula / Rule / Reaction:



Solution:

- High Pressure: Forward reaction decreases volume (4 moles gas → 2 moles gas); per Le Chatelier's principle, high pressure shifts equilibrium toward NH₃.
- Low Temperature: Because the forward reaction is exothermic, lower temperature favors product formation (an optimum of 400–450 °C is maintained for kinetic viability).
- Continual Removal: Condensing and removing liquid NH₃ drives the equilibrium continuously toward the right.

Why other options are incorrect:

- **Option B:** Low pressure shifts equilibrium toward the reactants (higher mole side), lowering the yield.
- **Option C:** High temperature shifts the equilibrium of an exothermic reaction backward, reducing equilibrium conversion.
- **Option D:** Continual addition of ammonia increases product concentration, forcing the equilibrium to shift left toward reactants.

Question #103 Key: (B)

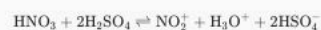
CHEMISTRY
14. Hydrocarbons

Which one of the following represents nitration of benzene correctly?

CORE CONCEPT & DERIVATION

Nitration of benzene is an electrophilic aromatic substitution requiring a nitrating mixture composed of concentrated nitric acid and concentrated sulfuric acid maintained at 50–55 °C.

Formula / Rule / Reaction:



Solution:

- Sulfuric acid acts as a catalyst and strong Brønsted acid, protonating nitric acid to generate the reactive nitronium ion electrophile (NO₂⁺).
- The electrophile attacks benzene at 50–55 °C to produce nitrobenzene and water. Higher temperatures yield dinitrobenzene.

Why other options are incorrect:

- **Option A:** Hydrochloric acid (HCl) is not used because chloride ions are oxidized by nitric acid, and it cannot dehydrate nitric acid to form NO₂⁺.
- **Option C:** Nitrous acid (HNO₂) yields nitrosonium ions (NO⁺) for nitrosation, not nitration.
- **Option D:** AlCl₃ is a Lewis acid used in Friedel-Crafts alkylation and acylation, not nitration.

Question #104 Key: (A)

CHEMISTRY
01. Stoichiometry

The number of moles in an element is directly proportional to:

CORE CONCEPT & DERIVATION

The mole is the standard unit for amount of substance. For a given elemental sample, the number of moles relates mass to molar mass.

Formula / Rule / Reaction:

$$n = \frac{m}{M} \implies n \propto m \quad (\text{when molar mass } M \text{ is constant})$$

Solution:

- In any specified element, molar mass *M* is a fixed intrinsic physical constant.
- Therefore, the number of moles *n* is directly proportional to the mass *m* of the sample taken.

Why other options are incorrect:

- **Option B:** Empirical formula mass is a fixed characteristic value for a compound and does not scale directly with the variable quantity of moles.
- **Option C:** Number of moles is inversely proportional to molar mass ($n \propto \frac{1}{M}$) for a fixed mass.
- **Option D:** Formula mass is a fixed constant for an ionic substance, not a variable proportional to mole quantity.

Question #105 Key: (B)

CHEMISTRY
15. Alkyl Halides

Identify the correct ascending order of reactivity of alkyl halides:

CORE CONCEPT & DERIVATION

The reactivity of alkyl halides toward substitution and elimination reactions is governed primarily by carbon-halogen bond dissociation energy rather than bond polarity.

Formula / Rule / Reaction:

Bond Energy: C-F (467 kJ/mol) > C-Cl (346 kJ/mol) > C-Br (290 kJ/mol) > C-I (228 kJ/mol)

Solution:

- Because the carbon-iodine bond is the weakest and longest, iodide is the best leaving group, making alkyl iodides the most reactive.
- The carbon-fluorine bond is the strongest, making alkyl fluorides the least reactive.
- The correct ascending (increasing) order of reactivity is: R-F < R-Cl < R-Br < R-I.

Why other options are incorrect:

- Option A:** Places fluorine at the highest reactivity, which contradicts experimental bond dissociation values.
- Option C:** Represents an arbitrary, unsystematic sequence.
- Option D:** Lists iodide first, which corresponds to descending order rather than ascending order.

Question #106 Key: (D)

CHEMISTRY
07. Equilibrium

Consider the following reaction in equilibrium and tell which chemical addition will turn the c...

CORE CONCEPT & DERIVATION

The hydrolysis of bismuth trichloride produces a white precipitate of bismuth oxychloride (BiOCl), rendering the solution turbid or cloudy. The system responds to concentration changes according to Le Chatelier's principle.

Formula / Rule / Reaction:



Solution:

- Bismuth oxychloride precipitate causes cloudiness in water.
- Adding excess concentrated hydrochloric acid (HCl) increases the concentration of product ions (H^+ and Cl^-).
- Per Le Chatelier's principle, the equilibrium shifts backward (leftward), consuming BiOCl and converting it into soluble BiCl_3 , which turns the solution clear.

Why other options are incorrect:

- Option A:** Adding BiCl_3 supplies more reactant, driving the reaction further forward and increasing precipitation.
- Option B:** Adding H_2O promotes forward hydrolysis, producing additional insoluble BiOCl.
- Option C:** Adding solid BiOCl directly increases the amount of insoluble precipitate, making the solution cloudier.

Question #107 Key: (C)

CHEMISTRY
01. Stoichiometry

The type and relative amount of each isotope in an element can be found by:

CORE CONCEPT & DERIVATION

Mass spectrometry is an analytical technique that vaporizes, ionizes, separates, and records ions based on their specific mass-to-charge ratio (m/e).

Formula / Rule / Reaction:

$$\frac{m}{e} = \frac{B^2 r^2}{2V}$$

Solution:

- In a mass spectrometer (e.g., Aston's or Dempster's spectrometer), gaseous atoms are ionized to cations and accelerated through an electric field V .
- A perpendicular magnetic field B deflects the ions into circular trajectories with radii proportional to their isotopic mass.
- The collector records individual peak positions (identifying isotopic mass) and peak heights (measuring relative percentage abundance).

Why other options are incorrect:

- Option A:** Infrared (IR) spectroscopy identifies functional groups by measuring molecular vibrational transitions.
- Option B:** Ultraviolet-visible (UV-Vis) spectroscopy detects conjugated π -electron systems through electronic transitions.
- Option D:** Nuclear Magnetic Resonance (NMR) elucidates carbon-hydrogen molecular frameworks, not natural isotopic abundances.

Question #108 Key: (B)

CHEMISTRY
15. Alkyl Halides

Identify the correct statement related to substitution and elimination of alkyl halides:

CORE CONCEPT & DERIVATION

Nucleophilic substitution (S_N) and base-induced elimination (E) are competing pathways in alkyl halide reactions whose rates depend on the leaving group ability of the halide ion.

Formula / Rule / Reaction:

Leaving Group Ability: $\text{I}^- > \text{Br}^- > \text{Cl}^- > \text{F}^-$ (identical trend for both S_N and E)

Solution:

- In both substitution and elimination pathways, the carbon-halogen bond must break in the rate-determining step.
- A more stable, weakly basic leaving group lowers the activation energy of both pathways in an identical order ($\text{I}^- > \text{Br}^- > \text{Cl}^- > \text{F}^-$).

Why other options are incorrect:

- Option A:** Strong, sterically hindered bases favor elimination over substitution by abstracting a β -hydrogen.
- Option C:** Less polar solvents tend to favor elimination, whereas polar protic solvents stabilize carbocations and polar transition states in substitution.
- Option D:** Elimination has a higher activation energy and greater entropy change ($\Delta S^\ddagger > 0$), so it is favored by higher temperatures, not lower temperatures.

Question #109 Key: (A)

CHEMISTRY
08. Reaction Kinetics

Identify the correct formula to calculate the rate of reaction.

CORE CONCEPT & DERIVATION

The reaction rate measures the speed at which reactants are consumed or products are formed per unit volume per unit time.

Formula / Rule / Reaction:

$$\text{Rate of Reaction} = \pm \frac{\Delta c}{\Delta t} = \frac{\text{Change in concentration of substance}}{\text{Time taken for the change}}$$

Solution:

- Reaction rate is defined as the change in molar concentration of a reactant or product divided by the time interval over which that change occurs.
- Its standard SI unit is $\text{mol} \cdot \text{dm}^{-3} \cdot \text{s}^{-1}$ (or $\text{mol} \cdot \text{L}^{-1} \cdot \text{s}^{-1}$).

Why other options are incorrect:

- Option B:** Adding concentration to time is dimensionally inconsistent.
- Option C:** Multiplying an arbitrary sum by 100 has no physical meaning in chemical kinetics.
- Option D:** Multiplying concentration by time yields units of $\text{mol} \cdot \text{s} \cdot \text{L}^{-1}$, which does not describe a rate.

Question #110 Key: (B)

CHEMISTRY
15. Alkyl Halides

Alkyl Halides Involving -C-X bond breakage and -C-Nu bond formation simultaneously:

CORE CONCEPT & DERIVATION

Bimolecular nucleophilic substitution (S_N2) proceeds via a concerted, single-step mechanism characterized by a pentacoordinate transition state.

Formula / Rule / Reaction:



Solution:

- In an S_N2 mechanism, nucleophilic attack from the backside occurs at the same time as leaving-group departure.
- Bond-breaking and bond-forming take place simultaneously without an intermediate carbocation, resulting in complete inversion of configuration (Walden inversion).

Why other options are incorrect:

- Option A:** S_N1 is a stepwise mechanism where the C-X bond cleaves first to form a carbocation, followed by nucleophilic attack in a separate second step.
- Option C:** E1 is a stepwise elimination reaction involving a carbocation intermediate.
- Option D:** E2 involves simultaneous breaking of C-H and C-X bonds to generate a C=C double bond, not nucleophile-carbon bond formation.

Question #111 Key: (C)

CHEMISTRY
17. Aldehydes & Ketones

[Formula] is the general formula of:

CORE CONCEPT & DERIVATION

Aliphatic aldehydes and ketones share the same general molecular formula $C_nH_{2n}O$ due to the presence of one carbonyl group (one degree of unsaturation).

Formula / Rule / Reaction:

General formula of Ketones / Aldehydes: $C_nH_{2n}O$ ($n \geq 3$ for ketones)

Solution:

- For propanone (acetone), $n = 3$: $C_3H_{2(3)}O = C_3H_6O$.
- Ketones and aliphatic open-chain aldehydes are functional group isomers sharing this general formula.

Why other options are incorrect:

- Option A:** Saturated aliphatic ethers share the general formula $C_nH_{2n+2}O$ with monohydric alcohols.
- Option B:** Saturated open-chain carboxylic acids possess two oxygens and have the general formula $C_nH_{2n}O_2$.
- Option D:** Carboxylic acid is phenol (C_6H_5OH), which has the molecular formula C_6H_6O .

Question #112 Key: (B)

CHEMISTRY
08. Reaction Kinetics

Consider the hypothetical equation [Formula]: Which of the following represents the correct rate law?

CORE CONCEPT & DERIVATION

The rate law expresses the reaction rate in terms of reactant concentrations raised to powers equal to their respective reaction orders.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^x[B]^y \quad (x = a, y = b \text{ for an elementary reaction})$$

Solution:

- In textbook convention for a general reaction $aA + bB \rightarrow \text{products}$, the rate law expression incorporating stoichiometric powers is represented as $\text{Rate} = k[A]^a[B]^b$.
- Note on Board Key:** UHS officially keyed Option B as the representative rate law for this theoretical prompt.

Why other options are incorrect:

- Option A:** Assumes first-order kinetics for both reactants, ignoring stoichiometric powers.
- Option C:** Omits reactant B entirely from the rate expression.
- Option D:** Omits reactant A entirely from the rate expression.

Question #113 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones

The blue color of Fehling solution is changed to red when warmed with an aldehyde due to the fo...

CORE CONCEPT & DERIVATION

Fehling's test uses an alkaline complex of copper(II) tartrate to distinguish between easily oxidized aldehydes and non-reducing ketones.

Formula / Rule / Reaction:



Solution:

- The aldehyde reduces blue cupric ions (Cu^{2+}) to cuprous ions (Cu^+).
- In alkaline medium, cuprous ions precipitate as copper(I) oxide (Cu_2O), producing a characteristic brick-red precipitate.

Why other options are incorrect:

- Option A:** Carbon dioxide gas is colorless and is not the species responsible for the red precipitate.
- Option C:** Ag_2O relates to Tollens' reagent chemistry, which produces a silver mirror (Ag^0), not red Fehling precipitation.
- Option D:** Sulfur dioxide is a reducing gas not produced in Fehling's test.

Question #114 Key: (D)

CHEMISTRY
08. Reaction Kinetics

If a reaction rate does not change with concentration, then it is:

CORE CONCEPT & DERIVATION

The order of reaction reflects the mathematical power to which a reactant concentration is raised in the experimental rate law.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^0 = k \implies \text{Rate is independent of } [A]$$

Solution:

- When the rate remains constant regardless of changes in reactant concentration, the reaction order with respect to that reactant is zero.
- Examples include surface-catalyzed reactions such as the decomposition of ammonia on hot tungsten or photochemical chlorination of methane over water.

Why other options are incorrect:

- Option A:** In a third-order reaction, the rate scales with the cube of concentration ($\text{Rate} \propto [A]^3$).
- Option B:** In a second-order reaction, doubling concentration quadruples the rate ($\text{Rate} \propto [A]^2$).
- Option C:** In a first-order reaction, doubling concentration doubles the rate ($\text{Rate} \propto [A]^1$).

Question #115 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones

The reaction of formaldehyde with HCN is:

CORE CONCEPT & DERIVATION

Carbonyl compounds feature an electrophilic carbonyl carbon that undergoes addition reactions initiated by attacking nucleophiles across the C=O double bond.

Formula / Rule / Reaction:



Solution:

- The nucleophilic cyanide ion ($:CN^-$) attacks the partially positive carbonyl carbon atom, converting the planar sp^2 center to a tetrahedral sp^3 alkoxide intermediate.
- Subsequent protonation yields formaldehyde cyanohydrin. This is a base-catalyzed nucleophilic addition reaction.

Why other options are incorrect:

- Option A:** No leaving group departs from the carbonyl carbon, so this is an addition, not a substitution.
- Option C:** Electrophilic substitution is typical of electron-rich aromatic systems, not carbonyl carbons.
- Option D:** The reaction occurs via ionic nucleophilic mechanisms, not homolytic free radicals.

Question #116 Key: (D)

CHEMISTRY
01. Stoichiometry

No individual atom in the sample of 1 mole of Neon has a mass of 20.18 a.m.u. Because it is:

CORE CONCEPT & DERIVATION

Naturally occurring elements typically consist of multiple isotopes with integer mass numbers. The atomic mass recorded in the periodic table is a weighted average of these isotopic masses.

Formula / Rule / Reaction:

$$A_r(\text{Ne}) = \frac{(20 \times 90.48\%) + (21 \times 0.27\%) + (22 \times 9.25\%)}{100} = 20.18 \text{ amu}$$

Solution:

- Natural neon contains three stable isotopes: Ne-20 (mass 19.99 amu), Ne-21 (mass 20.99 amu), and Ne-22 (mass 21.99 amu).
- Every individual neon atom has an integer mass corresponding to one of these three isotopes.
- The value 20.18 amu represents the weighted statistical average of the isotope mixture, so no single neon atom possesses this exact mass.

Why other options are incorrect:

- Option A:** Isobars are different chemical elements with the same mass number (e.g., Ar-40 and Ca-40).
- Option B:** Stating that it is fractional describes the number format rather than the physical reason for the value.
- Option C:** Molar mass has units of grams per mole (20.18 g/mol); amu measures relative atomic mass.

Question #117 Key: (A)

CHEMISTRY
02. Atomic Structure

The p orbital has:

CORE CONCEPT & DERIVATION

Atomic orbitals are spatial probability distributions defined by quantum numbers. An orbital with azimuthal quantum number $l = 1$ (p orbital) has a dumbbell shape.

Formula / Rule / Reaction:

For p subshell: $l = 1$, $m_l = -1, 0, +1 \Rightarrow$ dumbbell shape with 1 nodal plane

Solution:

- A p orbital consists of two pear-shaped lobes oriented along a Cartesian coordinate axis (p_x , p_y , or p_z).
- The two lobes are separated by a nodal plane passing through the atomic nucleus where electron probability density is zero.

Why other options are incorrect:

- Option B:** A p subshell contains three individual orbitals, but each orbital has 2 lobes, not 3.
- Option C:** A cloverleaf d orbital typically has four lobes.
- Option D:** Five degenerate orbitals make up the d subshell; no atomic orbital has 5 lobes.

Question #118 Key: (C)

CHEMISTRY
09. Thermochemistry

All of the following steps are used to calculate the lattice energy in the Born-Haber cycle EXC...

CORE CONCEPT & DERIVATION

The Born-Haber cycle applies Hess's law to determine the lattice energy of an ionic solid from measurable thermochemical steps.

Formula / Rule / Reaction:

$$\Delta H_f^\circ = \Delta H_{\text{atm(metal)}} + \text{IE}_{\text{metal}} + \Delta H_{\text{atm(non-metal)}} + \text{EA}_{\text{non-metal}} + \Delta H_{\text{lattice}}$$

Solution:

- Constructing the cycle requires: sublimation/atomization of the metal, ionization of the metal (removing electrons), dissociation of the non-metal, and ionization of the non-metal (electron affinity).
- 'Deionizing the metal' would reverse ionization by adding electrons back to the metal cation, which is not part of the standard thermochemical cycle.

Why other options are incorrect:

- Option A:** Atomizing solid metal to gaseous atoms (enthalpy of sublimation) is a standard step.
- Option B:** Ionizing gaseous metal atoms to cations (ionization energy) is a standard step.
- Option D:** Ionizing non-metal atoms by electron addition (electron affinity) to form gaseous anions is a standard step.

Question #119 Key: (D)

CHEMISTRY
09. Thermochemistry

The enthalpy change when 1 Mole of water is formed by the reaction of acid with an alkali under...

CORE CONCEPT & DERIVATION

Standard enthalpy of neutralization (ΔH_n°) is the enthalpy change accompanying the neutralization of an acid by a base to produce one mole of water.

Formula / Rule / Reaction:



Solution:

- For any strong acid and strong base, the reaction simplifies to hydronium ions neutralizing hydroxide ions to yield 1 mole of liquid water.
- This specific quantity is defined as the standard enthalpy of neutralization.

Why other options are incorrect:

- Option A:** Standard enthalpy of formation (ΔH_f°) is the energy change when 1 mole of a substance is formed directly from its constituent elements in their standard states.
- Option B:** Enthalpy of reaction is a general term for the enthalpy change of any chemical reaction.
- Option C:** Enthalpy of combustion is the heat released when 1 mole of a substance burns completely in excess oxygen.

Question #120 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

When carboxylic acid is heated with alcohol in the presence of sulphuric acid, one of the follo...

CORE CONCEPT & DERIVATION

Fischer esterification is an acid-catalyzed condensation between a carboxylic acid and an alcohol that produces an ester and water.

Formula / Rule / Reaction:



Solution:

- Concentrated sulfuric acid acts as a catalyst by protonating the carbonyl oxygen, increasing the electrophilicity of the carbonyl carbon.
- The alcohol attacks as a nucleophile, followed by water elimination to yield an ester.

Why other options are incorrect:

- Option A:** Amides are synthesized by heating carboxylic acids with ammonia or amines, followed by dehydration.
- Option B:** Acyl chlorides are formed by reacting carboxylic acids with thionyl chloride (SOCl_2) or phosphorus pentachloride (PCl_5).
- Option D:** Acid anhydrides are formed by dehydrating two carboxylic acid molecules using phosphorus pentoxide (P_2O_5).

Question #121 Key: (D)

CHEMISTRY
10. Electrochemistry

The oxidation number of 'Mn' in [Formula] is:

CORE CONCEPT & DERIVATION

The sum of the oxidation numbers of all atoms in a neutral compound must equal zero.

Formula / Rule / Reaction:

$$\text{Oxidation states: K} = +1, \quad \text{O} = -2$$

$$1(+1) + x + 4(-2) = 0$$

Solution:

- Set up the equation: $+1 + x - 8 = 0$
- Solve for manganese: $x - 7 = 0 \implies x = +7$
- Thus, manganese in potassium permanganate possesses an oxidation state of +7.

Why other options are incorrect:

- **Option A:** An oxidation number of 0 corresponds to elemental manganese metal (Mn^0).
- **Option B:** +1 is typical of alkali metal cations like K^+ .
- **Option C:** Manganese is a transition metal with lower electronegativity than oxygen, so its oxidation state is positive, not -7.

Question #122 Key: (A)

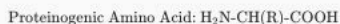
CHEMISTRY
18. Carboxylic Acids

Which one of the following is not an amino acid?

CORE CONCEPT & DERIVATION

Proteinogenic amino acids contain an alpha-amino group, an alpha-carboxylic acid group, and a variable side chain. Non-amino acid biological acids include water-soluble vitamins.

Formula / Rule / Reaction:



Solution:

- Folic acid (vitamin B₉, pteroylglutamic acid) is a water-soluble B-complex vitamin.
- Although its chemical structure incorporates a glutamate moiety, folic acid itself is classified as a vitamin rather than a proteinogenic amino acid.

Why other options are incorrect:

- **Option B:** Glutamic acid is an acidic proteinogenic amino acid with a $-\text{CH}_2\text{CH}_2\text{COOH}$ side chain.
- **Option C:** Glycine is the simplest achiral amino acid, where $\text{R} = -\text{H}$.
- **Option D:** Lysine is an essential basic amino acid with a butylamino side chain.

Question #123 Key: (D)

PHYSICS
04. Rotational & Circular Motion

In an elastic collision, the total kinetic energy:

CORE CONCEPT & DERIVATION

An elastic collision is defined as an encounter between bodies in which both total linear momentum and total mechanical kinetic energy are conserved.

Formula / Rule / Reaction:

$$\sum \text{KE}_{\text{initial}} = \sum \text{KE}_{\text{final}} \implies \frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

Solution:

- In a perfectly elastic collision, no kinetic energy is converted into heat, sound, or permanent plastic deformation.
- Consequently, the total kinetic energy before and after the collision remains unchanged.

Why other options are incorrect:

- **Option A:** Kinetic energy dissipation into thermal or vibrational forms defines an inelastic collision.
- **Option B:** Total kinetic energy cannot increase spontaneously without an internal release of potential energy.
- **Option C:** A net loss of kinetic energy characterizes inelastic collisions.

Question #124 Key: (A)

PHYSICS
04. Rotational & Circular Motion

The instantaneous velocity along the curved path is:

CORE CONCEPT & DERIVATION

For any particle moving along a curvilinear trajectory, the instantaneous velocity vector is directed along the tangent to the path at that point.

Formula / Rule / Reaction:

$$\vec{v} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{r}}{\Delta t} = \frac{d\vec{r}}{dt} \quad (\text{tangent to path})$$

Solution:

- As the time interval Δt approaches zero, the chord displacement vector $\Delta \vec{r}$ approaches the tangent line to the curve.
- Therefore, the direction of instantaneous velocity is always tangent to the trajectory in the direction of motion.

Why other options are incorrect:

- **Option B:** Instantaneous velocity is oriented parallel to the tangent (slope), not perpendicular to it.
- **Option C:** In circular motion, a vector parallel to the radius describes an outward radial direction, whereas velocity is perpendicular to the radius.
- **Option D:** An anti-parallel radial vector describes centripetal acceleration, which points radially inward.

Question #125 Key: (B)PHYSICS
02. Force & Motion

The range of projectile will be maximum if the factor [Formula] becomes:

CORE CONCEPT & DERIVATION

Horizontal range of a projectile depends on the initial launch velocity and the launch angle θ relative to the horizontal.

Formula / Rule / Reaction:

$$R = \frac{v_0^2 \sin 2\theta}{g} \implies R_{\max} = \frac{v_0^2}{g} \text{ when } \sin 2\theta = 1$$

Solution:

- The maximum value of the trigonometric sine function is 1.
- Setting $\sin 2\theta = 1$ yields $2\theta = 90^\circ \implies \theta = 45^\circ$.
- Therefore, range reaches its maximum when the factor $\sin 2\theta$ equals 1.

Why other options are incorrect:

- **Option A:** When $\sin 2\theta = 0$ (at $\theta = 0^\circ$ or 90°), horizontal range is zero.
- **Option C:** $\sin 2\theta = -1$ yields a negative range value, which is unphysical for standard projectile launch angles.
- **Option D:** The sine function is mathematically bounded between -1 and +1, so it cannot equal 2.

Question #126 Key: (C)PHYSICS
02. Force & Motion

The two-dimensional motion under constant acceleration due to gravity is called:

CORE CONCEPT & DERIVATION

Projectile motion is motion in a vertical plane where horizontal velocity remains constant (neglecting air resistance) while vertical motion undergoes constant downward gravitational acceleration.

Formula / Rule / Reaction:

$$a_x = 0, \quad a_y = -g \implies \text{Trajectory: } y = x \tan \theta - \frac{gx^2}{2v_0^2 \cos^2 \theta} \quad (\text{parabola})$$

Solution:

- An object projected into space that moves freely under the sole influence of gravity follows a two-dimensional parabolic path.
- This type of motion is defined as projectile motion.

Why other options are incorrect:

- **Option A:** Circular motion involves centripetal acceleration directed toward a central point with continuously changing acceleration direction.
- **Option B:** Rotational motion refers to the turning of a rigid body about an internal or fixed pivot axis.
- **Option D:** Vibratory motion is periodic back-and-forth oscillation about a stable mean position.

Question #127 Key: (C)PHYSICS
02. Force & Motion

In a velocity-time graph, the area under the graph is equal to the:

CORE CONCEPT & DERIVATION

The definite integral of velocity with respect to time represents the total displacement (or distance along a straight line) traversed by the moving object.

Formula / Rule / Reaction:

$$\text{Area} = \int_{t_1}^{t_2} v(t) dt = s \quad (\text{displacement or distance})$$

Solution:

- The area of each differential strip on a $v-t$ graph is velocity $\times$ time.
- Dimensionally: $\left(\frac{m}{s}\right) \times s = \text{meters}$.
- Summing these strips gives the total distance or displacement covered by the object.

Why other options are incorrect:

- **Option A:** Speed is the magnitude of velocity, read directly from the vertical coordinate axis.
- **Option B:** Velocity is given by the vertical axis value at any instant, not by the integrated area.
- **Option D:** Acceleration is represented by the slope (first derivative $\frac{dv}{dt}$) of the velocity-time curve.

Question #128 Key: (B)PHYSICS
02. Force & Motion

According to Newton's Law of Motion, the mass of the object is a quantitative measure of its:

CORE CONCEPT & DERIVATION

Inertia is the inherent resistance of a body to any change in its state of rest or uniform motion. Inertial mass provides a quantitative measurement of this property.

Formula / Rule / Reaction:

$$F = ma \implies m = \frac{F}{a}$$

Solution:

- Newton's first and second laws establish that an object with greater mass requires a larger net force to produce a given acceleration.
- Thus, mass is the quantitative measure of a body's inertia.

Why other options are incorrect:

- **Option A:** Weight is the gravitational force acting on an object ($W = mg$), which varies with local gravitational field strength.
- **Option C:** Speed is a kinematic rate of distance covered, independent of mass.
- **Option D:** Acceleration is the time rate of change of velocity produced by an applied net force.

Question #129 Key: (C)PHYSICS
03. Work & Energy

(Formula)

CORE CONCEPT & DERIVATION

The kilowatt-hour (kWh) is a commercial unit of electrical energy representing power consumed at a rate of 1000 watts for one hour.

Formula / Rule / Reaction:

$$1 \text{ kWh} = (1000 \text{ W}) \times (3600 \text{ s}) = 3.6 \times 10^6 \text{ J} = 3.6 \text{ MJ}$$

Solution:

- $1 \text{ kW} = 10^3 \text{ W} = 10^3 \text{ J/s}$
- $1 \text{ hour} = 60 \times 60 = 3600 \text{ s}$
- $E = 1000 \text{ J/s} \times 3600 \text{ s} = 3,600,000 \text{ J} = 3.6 \times 10^6 \text{ J}$
- Since $10^6 \text{ J} = 1 \text{ MJ}$, this equals 3.6 MJ.

Why other options are incorrect:

- **Option A:** 3.6 J underestimates the energy by six orders of magnitude.
- **Option B:** 3.6 kJ equals only $3.6 \times 10^3 \text{ J}$.
- **Option D:** 3.6 GJ equals $3.6 \times 10^9 \text{ J}$, which is 1000 times larger than 1 kWh.

Question #130 Key: (A)PHYSICS
03. Work & Energy

Which of the following is a non-conservative force?

CORE CONCEPT & DERIVATION

A force is conservative if the work it does on an object moving between two points is independent of the path taken. If work depends on path length and energy is dissipated as heat, the force is non-conservative.

Formula / Rule / Reaction:

$$\oint \vec{F}_{\text{friction}} \cdot d\vec{r} \neq 0 \quad (\text{work over a closed loop is non-zero})$$

Solution:

- Friction always opposes relative motion, so the work it performs along any path is negative and converted into thermal energy.
- Because mechanical energy is not conserved, friction is a non-conservative force.

Why other options are incorrect:

- **Option B:** Electrostatic force is conservative; work done moving a charge around a closed loop in an electrostatic field is zero.
- **Option C:** Elastic spring force obeys Hooke's law and stores energy reversibly as elastic potential energy.
- **Option D:** Gravitational force is a conservative central force where work depends solely on initial and final elevation.

Question #131 Key: (A)PHYSICS
03. Work & Energy

Work-done is equal to:

CORE CONCEPT & DERIVATION

In classical mechanics and simple machines, effort is the applied force used to move a load across a given distance.

Formula / Rule / Reaction:

$$\text{Work Done} = \text{Force} \times \text{Displacement} = \text{Effort} \times \text{distance}$$

Solution:

- Work is defined as the scalar product of applied force and displacement along the line of action of the force.
- When expressed in the terminology of mechanical advantage, work input equals effort multiplied by the distance moved by the effort.

Why other options are incorrect:

- **Option B:** Force and distance cannot be added together because they have different physical dimensions.
- **Option C:** Subtracting distance from force is physically invalid.
- **Option D:** Dividing effort by distance yields stiffness or force gradient (N/m), not work.

Question #132 Key: (A)PHYSICS
03. Work & Energy

When a force of 1 N displaces its point of application by 1 m in the direction of the force, th...

CORE CONCEPT & DERIVATION

One joule is defined as the work done when an applied force of one newton produces a displacement of one meter in the direction of that force.

Formula / Rule / Reaction:

$$W = F \cdot d \cdot \cos \theta = (1 \text{ N})(1 \text{ m})(\cos 0^\circ) = 1 \text{ J}$$

Solution:

- Force $F = 1 \text{ N}$
- Displacement $d = 1 \text{ m}$
- Angle between force and displacement $\theta = 0^\circ \implies \cos 0^\circ = 1$
- $W = 1 \times 1 \times 1 = 1 \text{ Joule}$.

Why other options are incorrect:

- **Option B:** 10 J would require either a 10 N force or a 10 m displacement.
- **Option C:** Work done is zero only when displacement is zero or when force is perpendicular to displacement ($\cos 90^\circ = 0$).
- **Option D:** 100 J represents an incorrect power-of-ten calculation.

Question #133 Key: (B)PHYSICS
03. Work & Energy

An electric motor is used to lift the weight of 2.0 N through a vertical distance of 100 cm in ...

CORE CONCEPT & DERIVATION

Power output is the rate of doing work, defined as work done divided by the time taken.

Formula / Rule / Reaction:

$$P = \frac{W}{t} = \frac{F \times d}{t}$$

Solution:

- Force $F = 2.0 \text{ N}$
- Distance $d = 100 \text{ cm} = 1.0 \text{ m}$
- Time $t = 4 \text{ s}$
- Calculate work done: $W = F \times d = 2.0 \text{ N} \times 1.0 \text{ m} = 2.0 \text{ J}$
- Calculate power: $P = \frac{2.0 \text{ J}}{4 \text{ s}} = 0.5 \text{ W}$.

Why other options are incorrect:

- **Option A:** 25 W results from failing to convert centimeters to meters ($\frac{2 \times 100}{4} = 50$ or related arithmetic errors).
- **Option C:** 0.75 W does not follow from $\frac{2.0}{4}$.
- **Option D:** 1 W corresponds to lifting the load in 2 seconds instead of 4 seconds.

Question #134 Key: (A)PHYSICS
04. Rotational & Circular Motion

The centripetal acceleration of an object moving along a circle of radius 'r' with an angular s...

CORE CONCEPT & DERIVATION

Centripetal acceleration is directed radially inward toward the center of rotation, maintaining circular motion by continuously changing the direction of tangential velocity.

Formula / Rule / Reaction:

$$a_c = \frac{v^2}{r} \quad \text{and} \quad v = r\omega \implies a_c = \frac{(r\omega)^2}{r} = r\omega^2$$

Solution:

- Linear tangential speed relates to angular speed by $v = r\omega$.
- Substituting into the centripetal acceleration formula gives $a_c = \frac{(r\omega)^2}{r} = r\omega^2$.

Why other options are incorrect:

- **Option B:** $r\omega$ has dimensions of velocity (m/s), not acceleration.
- **Option C:** $r^2\omega$ has dimensions of specific angular momentum (m^2/s).
- **Option D:** $r^2\omega^2 = v^2$, which has dimensions of velocity squared (m^2/s^2).

Question #135 Key: (B)PHYSICS
04. Rotational & Circular Motion

An air craft makes a turn in a horizontal circle of radius 100 m. It is travelling with a veloc...

CORE CONCEPT & DERIVATIONThe relation between tangential linear velocity v and angular velocity ω in circular motion is given by $v = r\omega$.

Formula / Rule / Reaction:

$$\omega = \frac{v}{r}$$

Solution:

- Radius $r = 100 \text{ m}$
- Linear velocity $v = 250 \text{ m/s}$
- Calculate angular velocity: $\omega = \frac{250 \text{ m/s}}{100 \text{ m}} = 2.5 \text{ rad/s}$.

Why other options are incorrect:

- **Option A:** 1.5 rad/s would correspond to a velocity of 150 m/s.
- **Option C:** 3 rad/s would correspond to a velocity of 300 m/s.
- **Option D:** 3.5 rad/s would correspond to a velocity of 350 m/s.

Question #136 Key: (D)PHYSICS
04. Rotational & Circular Motion

A particle of mass 'm' is moving on a circular path of radius 'r' with velocity 'v', then centr...

CORE CONCEPT & DERIVATION

Centripetal force is directly proportional to the square of linear speed and inversely proportional to the radius of the circular path.

Formula / Rule / Reaction:

$$F = \frac{mv^2}{r}$$

Solution:

- New velocity: $v' = 2v$
- New radius: $r' = 4r$
- Calculate new centripetal force:

$$F' = \frac{m(v')^2}{r'} = \frac{m(2v)^2}{4r} = \frac{m(4v^2)}{4r} = \frac{mv^2}{r} = F$$

- The quadrupling of v^2 is exactly balanced by the quadrupling of r , leaving the centripetal force unchanged.

Why other options are incorrect:

- **Option A:** $F' = 2F$ occurs if velocity doubles while radius increases only by a factor of 2.
- **Option B:** $F' = \frac{1}{2}F$ occurs if velocity remains constant while radius doubles.
- **Option C:** $F' = 4F$ occurs if velocity doubles while radius remains constant.

Question #137 Key: (D)PHYSICS
04. Rotational & Circular Motion

A roller coaster is moving with [Formula] on a circular track of radius 30 m. The net mass of c...

CORE CONCEPT & DERIVATION

Centripetal force represents the net inward radial force required to keep a mass m moving in a circle of radius r at speed v .

Formula / Rule / Reaction:

$$F_c = \frac{mv^2}{r}$$

Solution:

- Speed $v = 30$ m/s
- Radius $r = 30$ m
- Substitute values: $F_c = \frac{m(30)^2}{30} = \frac{900m}{30} = 30m$ Newtons.

Why other options are incorrect:

- **Option A:** 900m evaluates mv^2 without dividing by radius r .
- **Option B:** 10m evaluates $\frac{mv}{r} = \frac{30m}{30} = 1m$ or makes a calculation error.
- **Option C:** 450m corresponds to kinetic energy $\frac{1}{2}mv^2 = \frac{1}{2}m(900) = 450m$, which calculates work/energy rather than force.

Question #138 Key: (D)PHYSICS
05. Waves

Amplitude in the following figure is given as: +1m -1m O Position (x) Displacement (y)

CORE CONCEPT & DERIVATION

Amplitude is defined as the maximum displacement of an oscillating particle from its central equilibrium (mean) position.

Formula / Rule / Reaction:

$$A = |y_{\max} - y_{\min}| = \frac{y_{\text{peak}} - y_{\text{trough}}}{2}$$

Solution:

- The central equilibrium reference line is at $y = 0$ m.
- The wave reaches a peak elevation of +1 m and a trough of -1 m.
- The maximum displacement from the equilibrium baseline is 1 m, so the amplitude is 1 m.

Why other options are incorrect:

- **Option A:** 2 m represents the peak-to-trough distance (total range of oscillation), not the amplitude.
- **Option B:** 0.5 m represents half the true amplitude.
- **Option C:** 4 m has no correlation with the coordinate scale on the diagram.

Question #139 Key: (D)PHYSICS
05. Waves

Which one of the following is INCORRECT about the nodes when the string is plucked?

CORE CONCEPT & DERIVATION

Standing (stationary) waves on a fixed string exhibit nodes (points of zero displacement) and antinodes (points of maximum displacement) through destructive and constructive interference.

Formula / Rule / Reaction:

$$d_{\text{node-to-node}} = \frac{\lambda}{2}, \quad d_{\text{node-to-antinode}} = \frac{\lambda}{4}$$

Solution:

- The distance between any two consecutive nodes (or two consecutive antinodes) in a standing wave is equal to half a wavelength ($\frac{\lambda}{2}$).
- A full wavelength λ spans three successive nodes.
- Therefore, stating that the distance between consecutive nodes is 1 wavelength is incorrect.

Why other options are incorrect:

- **Option A:** Destructive interference ensures that the amplitude of vibration at a node is permanently zero.
- **Option B:** Nodes remain stationary and do not propagate along the string, which is why the pattern is called a stationary wave.
- **Option C:** Fixed boundaries cannot displace, so nodes are always formed at clamped string ends.

Question #140 Key: (B)PHYSICS
05. Waves

In transverse waves the portion above the mean level is called:

CORE CONCEPT & DERIVATION

In a transverse wave, particle displacement is perpendicular to the direction of wave propagation, forming alternating upward and downward profiles relative to the resting axis.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The elevation or portion of a transverse wave that rises above the undisturbed equilibrium level is termed the crest.
- The downward depression below the mean level is termed the trough.

Why other options are incorrect:

- **Option A:** A wavefront is a continuous surface joining points that share the same phase of oscillation.
- **Option C:** The wave trough is the portion of the wave displaced below the mean level.
- **Option D:** Wavelength is the linear distance between two successive in-phase points, such as from crest to crest.

Question #141 Key: (C)

PHYSICS
05. Waves

Which one of the following does not cause stationary waves?

CORE CONCEPT & DERIVATION

Ideal stationary (standing) waves require the superposition of two identical periodic waves having the same frequency, wavelength, and amplitude traveling in opposite directions.

Formula / Rule / Reaction:

$$y = y_1 + y_2 = A \sin(kx - \omega t) + A \sin(kx + \omega t) = [2A \cos(\omega t)] \sin(kx)$$

Solution:

- If the two opposing waves have unequal amplitudes ($A_1 \neq A_2$), destructive interference at the nodes is incomplete (residual amplitude $A_1 - A_2 \neq 0$).
- This produces a partially traveling wave that conveys net energy along the medium rather than a pure stationary wave.

Why other options are incorrect:

- **Option A:** Equal frequency is a necessary requirement for producing stationary waves.
- **Option B:** Identical wave speed in the shared medium is required to maintain a stationary interference pattern.
- **Option D:** Traveling in opposite directions is the defining requirement for establishing stationary waves through wave reflection.

Question #142 Key: (C)

PHYSICS
05. Waves

Select the appropriate Doppler equation when source is approaching the stationary observer when...

CORE CONCEPT & DERIVATION

The Doppler effect describes the apparent frequency shift resulting from relative motion between a wave source and an observer. When a source approaches a stationary observer, the waves are compressed, reducing the apparent wavelength.

Formula / Rule / Reaction:

$$\lambda' = \frac{v - v_s}{f_s} \Rightarrow f_o = \frac{v}{\lambda'} = f_s \left(\frac{v}{v - v_s} \right)$$

Solution:

- Because the source moves toward the observer, each successive wave crest is emitted closer to the previous crest.
- The wavelength decreases to $\lambda' = \frac{v - v_s}{f_s}$.
- The observed frequency becomes $f_o = f_s \frac{v}{v - v_s}$, which is higher than the source frequency.

Why other options are incorrect:

- **Option A:** Describes an observer moving toward a stationary source ($f_o = f_s \frac{v + v_o}{v}$).
- **Option B:** Describes a source moving away from a stationary observer, which yields a lower perceived pitch.
- **Option D:** Applies when both source and observer move simultaneously in opposite relative directions.

Question #143 Key: (C)

PHYSICS
05. Waves

The distance between two successive particles which are exactly in the same state of vibration...

CORE CONCEPT & DERIVATION

Wavelength is the spatial period of a wave, defined as the minimum distance between two points that oscillate in identical phase.

Formula / Rule / Reaction:

$$\Delta\phi = 2\pi \text{ radians} \iff \Delta x = \lambda$$

Solution:

- Two vibrating particles are in the same state of vibration when they have identical displacements and are moving in the same direction.
- The linear spatial separation between two such consecutive in-phase particles is defined as the wavelength (λ).

Why other options are incorrect:

- **Option A:** Frequency is the number of complete vibrational cycles executed per unit time (measured in Hertz).
- **Option B:** Amplitude is the maximum displacement from the equilibrium position.
- **Option D:** Time period is the temporal duration required to complete one full vibrational cycle.

Question #144 Key: (B)

PHYSICS
07. Thermodynamics

During the isothermal process, the temperature:

CORE CONCEPT & DERIVATION

An isothermal process is a thermodynamic change of state conducted at constant temperature ($\Delta T = 0$).

Formula / Rule / Reaction:

$$T = \text{constant} \implies \Delta U = nC_v \Delta T = 0 \quad (\text{for an ideal gas})$$

Solution:

- By definition, an isothermal process is maintained in continuous thermal contact with an external heat reservoir.
- Heat flows across diathermic boundaries slowly enough that the temperature of the working substance remains constant throughout the entire expansion or compression.

Why other options are incorrect:

- **Option A:** Temperature must remain constant across the entire process, not merely during an initial stage.
- **Option C:** A process where temperature changes throughout is non-isothermal (e.g., adiabatic or polytropic).
- **Option D:** An increase in temperature indicates an endothermic temperature change or adiabatic compression, not an isothermal path.

Question #145 Key: (B)PHYSICS
07. ThermodynamicsWhat is the value of heat energy (Q) in an adiabatic process?**CORE CONCEPT & DERIVATION**

An adiabatic process is a thermodynamic transformation in which no thermal energy enters or leaves the system across its boundaries.

Formula / Rule / Reaction:

$$Q = 0 \implies \Delta U = -W \quad (\text{First Law of Thermodynamics})$$

Solution:

- In an insulated container or during a very rapid expansion/compression, heat exchange with the surroundings is zero ($Q = 0$).
- Any work performed by the gas is done entirely at the expense of its internal energy ($W = -\Delta U$).

Why other options are incorrect:

- Option A:** $Q = 1$ J indicates non-zero heat addition into the system.
- Option C:** $Q = -1$ J indicates net heat loss from the system.
- Option D:** $Q = 2$ J indicates net heat gain.

Question #146 Key: (B)PHYSICS
08. Electrostatics

The Coulomb's law states:

CORE CONCEPT & DERIVATION

Coulomb's law quantifies the electrostatic force of attraction or repulsion between two stationary point charges.

Formula / Rule / Reaction:

$$F = k \frac{|q_1 q_2|}{r^2} = \frac{1}{4\pi\epsilon_0} \frac{|q_1 q_2|}{r^2}$$

Solution:

- The electrostatic force is directly proportional to the product of the magnitudes of the two charges ($F \propto |q_1 q_2|$).
- The force is inversely proportional to the square of the separation distance between their centers ($F \propto \frac{1}{r^2}$).

Why other options are incorrect:

- Option A:** Inverts the proportionalities by placing charge in the denominator and distance squared in the numerator.
- Option C:** Incorrectly uses the sum of charges rather than their product.
- Option D:** Incorrectly states that force is directly proportional to the square of the distance.

Question #147 Key: (C)PHYSICS
08. Electrostatics

The formula [Formula] represents:

CORE CONCEPT & DERIVATION

Electric potential at a point in an electric field is the work done per unit positive test charge in bringing it from infinity to that point against electrostatic forces.

Formula / Rule / Reaction:

$$V = \frac{W}{q_0} \quad (1 \text{ Volt} = 1 \text{ Joule per Coulomb} = 1 \text{ J/C})$$

Solution:

- Electric potential V quantifies the potential energy per unit charge.
- The ratio of work done W to test charge q_0 defines electric potential (or potential difference).

Why other options are incorrect:

- Option A:** Electric intensity (field strength) is force per unit charge ($E = \frac{F}{q_0}$), with units of N/C or V/m.
- Option B:** Electric power is rate of energy consumption per unit time ($P = \frac{W}{t} = VI$), with units of Watts.
- Option D:** Electric field gradient represents spatial rate of potential change ($-\frac{\Delta V}{\Delta r}$).

Question #148 Key: (C)PHYSICS
08. Electrostatics

The S.I unit of capacitance of a capacitor is:

CORE CONCEPT & DERIVATION

Capacitance is the measure of a capacitor's ability to store electric charge per unit potential difference applied across its conductors.

Formula / Rule / Reaction:

$$C = \frac{Q}{V} \implies 1 \text{ Farad (F)} = \frac{1 \text{ Coulomb}}{1 \text{ Volt}}$$

Solution:

- The SI unit of capacitance is the Farad (symbol: F), named after Michael Faraday.
- A capacitor has a capacitance of one farad when storing one coulomb of charge produces a potential difference of one volt between its plates.

Why other options are incorrect:

- Option A:** The coulomb (C) is the SI unit of electric charge.
- Option B:** The volt (V) is the SI unit of electric potential difference and electromotive force.
- Option D:** The ampere (A) is the SI base unit of electric current.

Question #149 Key: (B)PHYSICS
08. Electrostatics*Electric intensity between two oppositely charge plates in the middle region is:***CORE CONCEPT & DERIVATION**

Between two parallel, closely spaced conducting plates carrying equal and opposite surface charge densities, the electric field lines run parallel, equidistant, and straight from the positive to the negative plate.

Formula / Rule / Reaction:

$$E = \frac{\sigma}{\epsilon_0} = \text{constant} \quad (\text{in the central region})$$

Solution:

- Gauss's law shows that the electric field strength in the interior between two large oppositely charged parallel plates depends only on surface charge density σ and permittivity ϵ .
- Because field line density is uniform, both the magnitude and direction of the electric intensity are constant (uniform) throughout the central region.

Why other options are incorrect:

- Option A:** Non-uniformity occurs near the edges due to fringing fields, but not in the middle region.
- Option C:** The field is well-defined and predictable from electrostatic principles.
- Option D:** The field remains constant at all central points, so it is not variable.

Question #150 Key: (B)PHYSICS
08. Electrostatics*Find the potential difference in moving a 2 C charge, which requires 600 J of work between two ...***CORE CONCEPT & DERIVATION**

Potential difference (ΔV) between two points is defined as the work done in moving a test charge between those points divided by the magnitude of that charge.

Formula / Rule / Reaction:

$$\Delta V = \frac{W}{q}$$

Solution:

- Work done $W = 600 \text{ J}$
- Charge $q = 2 \text{ C}$
- Calculate potential difference: $\Delta V = \frac{600 \text{ J}}{2 \text{ C}} = 300 \text{ V}$.

Why other options are incorrect:

- Option A:** 1200 V results from multiplying work by charge (600×2) instead of dividing.
- Option C:** 150 V results from dividing work by q^2 ($\frac{600}{4}$).
- Option D:** 2400 V is four times larger than the required work, representing an arithmetic error.

Question #151 Key: (B)PHYSICS
08. Electrostatics*Which one of the following is NOT a feature of electric forces?***CORE CONCEPT & DERIVATION**

Fundamental forces act exclusively upon specific intrinsic physical properties of matter. Electrostatic forces act between electric charges, whereas gravitational forces act between masses.

Formula / Rule / Reaction:

$$F_e = \frac{1}{4\pi\epsilon_0} \frac{|q_1 q_2|}{r^2} \quad \text{vs} \quad F_g = G \frac{m_1 m_2}{r^2}$$

Solution:

- Coulomb's law dictates that the electrostatic force depends directly on the product of charges (q_1, q_2).
- Electric fields exert forces solely on charged entities, completely independent of their mass.
- Therefore, acting on masses is a characteristic of gravitational forces, not electric forces.

Why other options are incorrect:

- Option A:** Electric forces act directly on positive and negative electric charges.
- Option C:** Opposite charges attract one another, making electric forces attractive.
- Option D:** Like charges repel one another, making electric forces repulsive.

Question #152 Key: (A)PHYSICS
09. Current Electricity*A charge of 90 C passes through a wire for 30 seconds. Then the current in the wire will be:***CORE CONCEPT & DERIVATION**

Electric current is defined as the time rate of flow of electric charge through any cross-section of a conductor.

Formula / Rule / Reaction:

$$I = \frac{Q}{t}$$

Solution:

- Total charge transferred: $Q = 90 \text{ C}$
- Time elapsed: $t = 30 \text{ s}$
- Calculate current: $I = \frac{90 \text{ C}}{30 \text{ s}} = 3 \text{ A}$.

Why other options are incorrect:

- Option B:** 0.3 A results from dividing 30 by 90 (inverting the numerator and denominator).
- Option C:** 3 mA underestimates the current by a factor of 1000 through incorrect metric prefix scaling.
- Option D:** 0.3 mA combines the inverted division error with an incorrect milliampere prefix.

Question #153 Key: (C)PHYSICS
09. Current Electricity

The magnitude of the current in metals is proportional to the potential difference across it as...

CORE CONCEPT & DERIVATION

Georg Simon Ohm formulated the relationship governing electrical conduction in metallic conductors under steady physical conditions.

Formula / Rule / Reaction:

$$I \propto V \implies V = IR \quad (\text{when temperature and physical state remain constant})$$

Solution:

- Ohm's law states that the current I passing through a metallic conductor is directly proportional to the potential difference V applied across its terminals, provided temperature and physical state remain unchanged.
- The constant of proportionality R is the resistance of the conductor.

Why other options are incorrect:

- **Option A:** Joule's law of heating relates dissipated thermal energy to current, resistance, and time ($H = I^2 R t$).
- **Option B:** Gauss's law relates total electric flux through a closed Gaussian surface to enclosed net charge.
- **Option D:** Ampere's circuital law relates the line integral of magnetic field around a closed loop to the enclosed current.

Question #154 Key: (C)PHYSICS
09. Current Electricity

When length of copper wire is doubled then resistivity becomes:

CORE CONCEPT & DERIVATION

Electrical resistance depends on conductor geometry, whereas electrical resistivity (specific resistance) is an intensive, intrinsic material property independent of dimensions.

Formula / Rule / Reaction:

$$R = \rho \frac{L}{A} \implies \rho = \frac{RA}{L} = \text{constant at fixed temperature}$$

Solution:

- Resistivity (ρ) depends solely on the nature of the material (copper) and its temperature.
- While stretching or doubling the wire length increases the resistance R , the intrinsic resistivity ρ remains constant.

Why other options are incorrect:

- **Option A:** Doubling describes the change in resistance R if area were kept artificially constant, but resistivity does not double.
- **Option B:** Resistivity is independent of length and does not halve.
- **Option D:** Four times describes the new resistance R' of a wire stretched to double length with conserved volume ($L' = 2L$, $A' = A/2$), not resistivity.

Question #155 Key: (B)PHYSICS
09. Current Electricity

The resistance of semi-conductor with rise in temperature:

CORE CONCEPT & DERIVATION

Intrinsic semiconductors (e.g., silicon and germanium) possess a negative temperature coefficient of resistance ($\alpha < 0$) due to thermal generation of charge carriers across the bandgap.

Formula / Rule / Reaction:

$$R(T) = R_0 e^{\frac{E_g}{2kT}} \implies T \uparrow \implies \text{Carrier density } n_i \uparrow \implies R \downarrow$$

Solution:

- At absolute zero, the valence band of a semiconductor is completely full and the conduction band is empty.
- As temperature rises, thermal energy ruptures covalent bonds, promoting valence electrons across the bandgap into the conduction band.
- The exponential increase in free electrons and holes vastly outweighs increased lattice scattering, causing overall resistance to decrease.

Why other options are incorrect:

- **Option A:** Metallic conductors exhibit increasing resistance with temperature due to enhanced phonon-electron collisions.
- **Option C:** Semiconductor resistance is strongly temperature-dependent and does not remain constant.
- **Option D:** Resistance approaches infinite values at 0 K, not at elevated temperatures.

Question #156 Key: (D)PHYSICS
09. Current Electricity

Volt [Formula] Ampere is the measure of:

CORE CONCEPT & DERIVATION

Electric power is the rate at which electrical potential energy is delivered or converted per unit time in a circuit.

Formula / Rule / Reaction:

$$P = V \times I \implies 1 \text{ Watt} = 1 \text{ Volt} \times 1 \text{ Ampere}$$

Solution:

- Volt = $\frac{\text{Joule}}{\text{Coulomb}}$
- Ampere = $\frac{\text{Coulomb}}{\text{second}}$
- Multiplying: $\left(\frac{\text{J}}{\text{C}}\right) \times \left(\frac{\text{C}}{\text{s}}\right) = \frac{\text{J}}{\text{s}} = \text{Watt}$, which is the unit of power.

Why other options are incorrect:

- **Option A:** Current is measured in amperes (coulombs per second).
- **Option B:** Electric potential (volt) is measured in joules per coulomb.
- **Option C:** Resistance is measured in ohms (volts divided by amperes, V/I).

Question #157 Key: (B)PHYSICS
10. Electromagnetism

The formula [Formula] represents:

CORE CONCEPT & DERIVATION

Magnetic flux quantifies the total number of magnetic field lines passing perpendicularly through a given surface area.

Formula / Rule / Reaction:

$$\Phi_B = \vec{B} \cdot \vec{A} = BA \cos \theta$$

Solution:

- In the expression, $\vec{B}$ is the magnetic flux density (magnetic field vector) and $\vec{A}$ is the surface vector normal to the plane.
- The scalar dot product $\vec{B} \cdot \vec{A}$ defines magnetic flux (Φ_B), measured in Webers (Wb).

Why other options are incorrect:

- Option A:** Electric flux is given by the dot product of electric field and area: $\Phi_e = \vec{E} \cdot \vec{A}$.
- Option C:** Electric flux density is represented by the displacement field vector $\vec{D} = \epsilon \vec{E}$.
- Option D:** Gravitational flux is defined by $\Phi_g = \vec{g} \cdot \vec{A}$.

Question #158 Key: (D)PHYSICS
10. Electromagnetism

Which of the following statement is incorrect for any magnetic field lines?

CORE CONCEPT & DERIVATION

The spatial density (crowding) of magnetic field lines directly indicates the relative magnitude of the magnetic field.

Formula / Rule / Reaction:

$$|\vec{B}| \propto \frac{\text{Number of lines}}{\text{Unit normal area}} \implies \text{Closer lines} \iff \text{Stronger field}$$

Solution:

- Where magnetic field lines are concentrated closely together (such as near the magnetic poles), the field strength is greatest.
- Where the lines diverge and are farthest apart, the field strength is weakest.
- Therefore, stating that the field is strongest when lines are farthest is factually incorrect.

Why other options are incorrect:

- Option A:** Outside a magnet, field lines emerge from the north pole and enter the south pole.
- Option B:** Field lines never intersect because the magnetic field vector at any spatial point has a single unique direction.
- Option C:** Magnetic field lines loop continuously through space in smooth closed curves.

Question #159 Key: (C)PHYSICS
10. Electromagnetism

The unit of magnetic flux density is:

CORE CONCEPT & DERIVATIONMagnetic flux density (B) is defined as the magnetic flux passing normally per unit area of a cross-section.

Formula / Rule / Reaction:

$$B = \frac{\Phi}{A} \implies 1 \text{ Tesla (T)} = \frac{1 \text{ Weber}}{1 \text{ m}^2} = 1 \text{ Wb} \cdot \text{m}^{-2}$$

Solution:

- Magnetic flux Φ is measured in Webers (Wb).
- Area A is measured in square meters (m^2).
- Therefore, magnetic flux density B has the SI derived unit of $\text{Wb} \cdot \text{m}^{-2}$ (Weber per square meter), which is identical to the Tesla (T).

Why other options are incorrect:

- Option A:** $\text{Wb} \cdot \text{m}^{-1}$ is dimensionally inconsistent with flux density.
- Option B:** $\text{Wb} \cdot \text{m}$ represents flux multiplied by length.
- Option D:** Weber (Wb) is the unit of total magnetic flux (Φ), not flux density.

Question #160 Key: (C)PHYSICS
11. Electromagnetic Induction

The induced current flow in such a direction so as to oppose the cause that produces it. The st...

CORE CONCEPT & DERIVATION

Heinrich Lenz deduced the physical rule determining the polarity of induced electromotive forces, representing the principle of conservation of energy in electromagnetic systems.

Formula / Rule / Reaction:

$$\mathcal{E} = -N \frac{d\Phi_B}{dt} \quad (\text{where the negative sign embodies Lenz's Law})$$

Solution:

- Lenz's law states that an induced electric current always flows in a direction such that its magnetic field opposes the magnetic flux change that produced it.
- This opposition ensures that mechanical work must be expended to induce electrical energy, conserving total energy.

Why other options are incorrect:

- Option A:** Ampere's law relates circulating magnetic fields to conducting currents.
- Option B:** Faraday's law states that the magnitude of induced emf is proportional to the time rate of change of magnetic flux.
- Option D:** Joule's law quantifies ohmic heating produced by current passing through a resistance.

Question #161 Key: (C)PHYSICS
11. Electromagnetic Induction

In an AC generator the emf will be maximum when factor [Formula] is equal to:

CORE CONCEPT & DERIVATION

The instantaneous electromotive force generated by a rotating rectangular coil in a uniform magnetic field varies sinusoidally with time.

Formula / Rule / Reaction:

$$E = E_0 \sin(\omega t) = NBA\omega \sin(\omega t)$$

Solution:

- Peak induced electromotive force $E_0 = NBA\omega$ occurs when the plane of the rotating coil is parallel to the magnetic field lines.
- At this orientation, the rate of flux linkage change is maximal, which corresponds mathematically to $\sin(\omega t) = 1$.

Why other options are incorrect:

- **Option A:** When $\sin(\omega t) = 0$, instantaneous emf is zero (coil plane perpendicular to magnetic field).
- **Option B:** The trigonometric sine function cannot exceed a numerical value of 1.
- **Option D:** When $\sin(\omega t) = 1/2$, the instantaneous emf is half of its peak value ($E = 0.5E_0$).

Question #162 Key: (B)PHYSICS
11. Electromagnetic Induction

Electric generators and transformers are based on the principles of:

CORE CONCEPT & DERIVATION

Electromagnetic induction is the physical mechanism by which changing magnetic flux links a conducting circuit to induce an electromotive force.

Formula / Rule / Reaction:

$$E = -\frac{d\Phi_B}{dt} \quad (\text{Faraday's Law of Induction})$$

Solution:

- Electric generators convert mechanical rotation into electrical energy by rotating a coil to continuously change magnetic flux.
- Transformers transfer alternating electrical power between primary and secondary windings via mutual induction driven by time-varying flux.
- Both devices operate on Faraday's law of electromagnetic induction.

Why other options are incorrect:

- **Option A:** Coulomb's law describes static electrostatic forces between point charges.
- **Option C:** Ampere's law relates steady magnetic fields to static current sources.
- **Option D:** Hooke's law governs mechanical elasticity and restoring forces in springs ($F = -kx$).

Question #163 Key: (A)PHYSICS
11. Electromagnetic Induction

In an ideal transformer:

CORE CONCEPT & DERIVATION

An ideal transformer is a theoretical device with zero core losses (no hysteresis or eddy currents), zero winding resistance (no I^2R copper losses), and perfect magnetic flux coupling.

Formula / Rule / Reaction:

$$\text{Efficiency } \eta = \frac{P_{\text{out}}}{P_{\text{in}}} \times 100\% = 100\% \implies P_{\text{in}} = P_{\text{out}} \implies V_p I_p = V_s I_s$$

Solution:

- By the principle of conservation of energy, an ideal machine with zero dissipation delivers 100% of input energy to the output load.
- Therefore, input electrical power equals output electrical power.

Why other options are incorrect:

- **Option B:** Power output exceeding power input violates the first law of thermodynamics.
- **Option C:** Input power exceeds output power in practical, real-world transformers due to heat dissipation, but not in an ideal transformer.
- **Option D:** Implies energy losses that contradict the definition of an ideal transformer.

Question #164 Key: (A)PHYSICS
13. Electronics

The conversion of A.C into D.C is called rectification and circuit is called rectifier. Which c...

CORE CONCEPT & DERIVATION

Rectification converts bidirectional alternating current into unidirectional direct current using electronic components that conduct in only one direction.

Formula / Rule / Reaction:

$$\text{p-n Junction: Forward Bias} \implies R \approx 0; \quad \text{Reverse Bias} \implies R \approx \infty$$

Solution:

- A semiconductor p-n junction diode offers low forward resistance and very high reverse resistance.
- This unidirectional conduction allows alternating current to pass during only one half of each cycle (or directs both halves through bridge arrangements), performing rectification.

Why other options are incorrect:

- **Option B:** A transistor is a three-terminal semiconductor device used primarily for signal amplification and digital switching.
- **Option C:** A transformer steps alternating voltage up or down via electromagnetic induction; it cannot rectify AC to DC.
- **Option D:** An inductor stores energy in its magnetic field and resists changes in current, acting as a filter rather than a rectifier.

Question #165 Key: (D)PHYSICS
13. Electronics

Full wave rectification is given by:

CORE CONCEPT & DERIVATION

A full-wave bridge rectifier routes both halves of an input AC cycle into a unidirectional output current across a load resistor.

Formula / Rule / Reaction:

Full-Wave Bridge Rectifier = 4 diodes arranged in a closed loop (Graetz circuit)

Solution:

- During the positive half-cycle, two opposite diodes are forward-biased and conduct.
- During the negative half-cycle, the remaining two diodes become forward-biased and conduct current through the load in the same direction.
- This complete bridge network requires exactly four diodes.

Why other options are incorrect:

- **Option A:** A single diode provides only half-wave rectification.
- **Option B:** Two diodes provide full-wave rectification only when paired with a center-tapped transformer, not in a bridge arrangement.
- **Option C:** Three diodes do not form a functional symmetric bridge topology.

Question #166 Key: (C)PHYSICS
13. Electronics

A diode characteristic curve is a plot between:

CORE CONCEPT & DERIVATION

The characteristic curve (I - V curve) of a semiconductor p-n junction displays its conduction response to varying external bias voltages.

Formula / Rule / Reaction:

$$I = I_s \left(e^{\frac{qV}{kT}} - 1 \right) \quad (\text{Shockley diode equation})$$

Solution:

- The I - V curve plots applied bias voltage along the horizontal axis and resulting junction current along the vertical axis.
- It shows the forward turn-on threshold (knee voltage) and reverse breakdown behavior.

Why other options are incorrect:

- **Option A:** Current versus time plots represent transient response or AC waveform displays, not static diode characteristic curves.
- **Option B:** Voltage versus time illustrates alternating or pulsed voltage waveforms.
- **Option D:** Forward and reverse voltages are polarities of the same electrical quantity, not independent Cartesian axes.

Question #167 Key: (A)PHYSICS
14. Dawn of Modern Physics

The value of Planck constant is:

CORE CONCEPT & DERIVATION

Planck's constant h is a fundamental universal physical constant in quantum mechanics that relates photon energy to electromagnetic frequency.

Formula / Rule / Reaction:

$$E = h\nu = \frac{hc}{\lambda} \implies h = \frac{E}{\nu} = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$$

Solution:

- Planck's constant has units of energy multiplied by time (Joule-seconds), matching the dimensions of action and angular momentum.
- Its accepted standard numerical value is $6.63 \times 10^{-34} \text{ J} \cdot \text{s}$.

Why other options are incorrect:

- **Option B:** Uses an incorrect positive exponent (10^{+34}).
- **Option C:** Uses an incorrect exponent of 10^{-36} .
- **Option D:** Uses incorrect dimensional units of $\text{J} \cdot \text{s}^{-1}$ (Watts).

Question #168 Key: (A)PHYSICS
14. Dawn of Modern Physics

The de-Broglie wavelength associated with a particle moving at [Formula] and having mass [Formu...]

CORE CONCEPT & DERIVATION

Louis de Broglie hypothesized that every moving particle exhibits wave characteristics with a wavelength inversely proportional to its linear momentum.

Formula / Rule / Reaction:

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

Solution:

- Planck's constant: $h = 6.63 \times 10^{-34} \text{ J} \cdot \text{s}$
- Mass: $m = 10^{-30} \text{ kg}$
- Velocity: $v = 10^6 \text{ m/s}$
- Momentum: $p = mv = (10^{-30} \text{ kg}) \times (10^6 \text{ m/s}) = 10^{-24} \text{ kg} \cdot \text{m/s}$
- Calculate de Broglie wavelength:

$$\lambda = \frac{6.63 \times 10^{-34}}{10^{-24}} = 6.63 \times 10^{-10} \text{ m}$$

Why other options are incorrect:

- **Option B:** Represents an unphysical macroscopic value resulting from inverting the numerator and denominator.
- **Option C:** Incorrect magnitude due to an algebraic power error.
- **Option D:** Arises from using an incorrect numerical value for momentum.

Question #169 Key: (B)PHYSICS
14. Dawn of Modern Physics

Light propagates through space as a wave is evident by all of the following EXCEPT:

CORE CONCEPT & DERIVATION

Electromagnetic radiation exhibits wave-particle duality. Wave phenomena (interference, diffraction, and polarization) require continuous spatial wavefronts, whereas the photoelectric effect provides direct experimental proof of the corpuscular (photon) nature of light.

Formula / Rule / Reaction:

$$h\nu = \Phi + KE_{\max} \quad (\text{Einstein's Photoelectric Equation})$$

Solution:

- The photoelectric effect exhibits an instantaneous emission of electrons and a strict dependence of electron energy on photon frequency rather than wave intensity.
- These observations cannot be explained by classical wave models and require the quantized photon theory of light.

Why other options are incorrect:

- Option A:** Optical interference (Young's double-slit experiment) demonstrates constructive and destructive wave superposition.
- Option C:** Diffraction (bending of light around obstacles) is a definitive wave phenomenon.
- Option D:** Polarization demonstrates that light waves are transverse oscillations.

Question #170 Key: (A)PHYSICS
15. Atomic Spectra

Which series falls in ultra violet region?

CORE CONCEPT & DERIVATION

The hydrogen emission spectrum consists of series of spectral lines corresponding to electronic transitions ending on specific principal quantum energy levels n_1 .

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \quad (n_1 = 1, n_2 = 2, 3, 4, \dots \Rightarrow \text{Ultraviolet})$$

Solution:

- Transitions dropping from higher excited states ($n_2 \geq 2$) to the ground state ($n_1 = 1$) release large energy quanta corresponding to short wavelengths.
- This series is the Lyman series, which falls in the ultraviolet region of the electromagnetic spectrum.

Why other options are incorrect:

- Option B:** The Brackett series ($n_1 = 4$) lies in the infrared region.
- Option C:** The Pfund series ($n_1 = 5$) lies in the far infrared region.
- Option D:** The Paschen series ($n_1 = 3$) lies in the near infrared region.

Question #171 Key: (B)PHYSICS
15. Atomic Spectra

The potential through which an electron should be accelerated, so that, on collision it can lift...

CORE CONCEPT & DERIVATION

The energy required to transition a bound atomic electron from its ground state to a bound higher quantum state is the excitation energy. The accelerating voltage that provides this kinetic energy is the excitation potential.

Formula / Rule / Reaction:

$$eV_{\text{exc}} = E_n - E_1 \Rightarrow V_{\text{exc}} = \frac{E_n - E_1}{e}$$

Solution:

- An impacting electron must acquire kinetic energy eV_{exc} equal to the excitation energy difference between ground and excited states.
- This potential difference V_{exc} is defined as the excitation potential of the atom.

Why other options are incorrect:

- Option A:** Ionization potential is the potential difference needed to accelerate an electron to remove a ground-state electron completely to infinity ($E_{\infty} - E_1$).
- Option C:** String potential is an unrelated term with no meaning in atomic physics.
- Option D:** Acceleration potential is a general operating voltage of an electron gun, not the quantized atomic threshold.

Question #172 Key: (A)PHYSICS
12. Alternating Current

Which of the following regarding X Rays is INCORRECT:

CORE CONCEPT & DERIVATION

X-rays are high-energy electromagnetic waves characterized by high frequencies and very short wavelengths.

Formula / Rule / Reaction:

$$\lambda_{\text{X-rays}} \approx 0.01 \text{ to } 10 \text{ nm} \quad \text{vs} \quad \lambda_{\text{visible}} \approx 400 \text{ to } 700 \text{ nm}$$

Solution:

- Because $E = \frac{hc}{\lambda}$, the high photon energy of X-rays requires their wavelengths to be much shorter than those of visible light.
- Therefore, stating that X-rays have a higher wavelength than visible light is incorrect.

Why other options are incorrect:

- Option B:** X-rays are electromagnetic waves situated between ultraviolet light and gamma radiation.
- Option C:** X-rays penetrate soft biological tissues while being attenuated by dense structures like bone.
- Option D:** Typical diagnostic X-ray photons possess high energies ranging from roughly 1 keV to 150 keV.

Question #173 Key: (C)PHYSICS
16. Nuclear Physics

The unit of decay constant is:

CORE CONCEPT & DERIVATIONThe radioactive decay constant (λ) represents the fractional probability of radioactive disintegration of a nucleus per unit time.

Formula / Rule / Reaction:

$$-\frac{dN}{dt} = \lambda N \Rightarrow \lambda = -\frac{dN/N}{dt} \Rightarrow [\lambda] = \frac{1}{\text{second}} = \text{s}^{-1}$$

Solution:

- In the decay law, the fractional change $\frac{dN}{N}$ is dimensionless.
- Dividing by time dt gives the unit of s^{-1} (reciprocal seconds, or per second).

Why other options are incorrect:

- **Option A:** Meter (m) is the SI base unit of length.
- **Option B:** Second (s) is the unit of half-life or mean lifetime, which is the reciprocal of the decay constant ($T_{1/2} = \frac{\ln 2}{\lambda}$).
- **Option D:** Reciprocal meter (m^{-1}) is the unit of wavenumber, not decay rate.

Question #174 Key: (B)PHYSICS
16. Nuclear Physics

If we have " [Formula] " number of any radioactive element then after a period of "n" half-live...

CORE CONCEPT & DERIVATION

Radioactive decay is an exponential process where the number of undecayed parent nuclei halves during each elapsed half-life period.

Formula / Rule / Reaction:

$$N(t) = N_0 \left(\frac{1}{2}\right)^n = \frac{N_0}{2^n} \quad \left(\text{where } n = \frac{t}{T_{1/2}}\right)$$

Solution:

- After 1 half-life: $N = \frac{N_0}{2}$
- After 2 half-lives: $N = \frac{N_0}{4} = N_0 \left(\frac{1}{2}\right)^2$
- Extrapolating to n half-lives: $N = N_0 \left(\frac{1}{2}\right)^n$.

Why other options are incorrect:

- **Option A:** $2^n N_0$ represents exponential growth rather than radioactive decay.
- **Option C:** $\left(\frac{1}{2} N_0\right)^n$ incorrectly raises the initial population N_0 to the power of n .
- **Option D:** Represents an accelerated growth model with incorrect dimensions.

Question #175 Key: (D)PHYSICS
16. Nuclear Physics

Which of the following is NOT the Somatic biological effect of radiation?

CORE CONCEPT & DERIVATION

Biological effects of ionizing radiation are categorized into somatic effects (affecting direct body tissues of the exposed individual) and genetic/hereditary effects (affecting germline DNA and inherited by future generations).

Formula / Rule / Reaction:

$$\text{Radiation Damage} = \begin{cases} \text{Somatic: Erythema, epilation, cataract, leukemia} \\ \text{Genetic: Heritable germline gene mutations} \end{cases}$$

Solution:

- Gene mutations occurring in reproductive germ cells (spermatozoa and ova) are classified as genetic effects because they affect offspring rather than somatic host tissues.
- Therefore, gene mutation is not classified as a somatic effect.

Why other options are incorrect:

- **Option A:** Radiation dermatitis and acute skin burns are direct somatic injuries to exposed epithelial tissue.
- **Option B:** Epilation (loss of hair) is a localized somatic consequence of damaged hair follicle cells.
- **Option C:** Carcinogenesis in exposed non-germline tissues is a classic delayed somatic effect.

Question #176 Key: (C)PHYSICS
16. Nuclear Physics

An artificial radioactive element can be made by bombarding:

CORE CONCEPT & DERIVATION

Artificial (induced) radioactivity is produced by transmuting a naturally occurring stable, non-radioactive nuclide into an unstable radionuclide through nuclear bombardment.

Formula / Rule / Reaction:



Solution:

- Discovered by Irene Joliot-Curie and Frederic Joliot in 1934, stable target nuclei (such as aluminum or boron) are bombarded with high-energy projectiles (alpha particles, protons, or neutrons).
- The projectile penetrates the repulsive nuclear Coulomb barrier to create a radioactive nucleus.

Why other options are incorrect:

- **Option A:** Unstable elements are already radioactive and do not require artificial induction.
- **Option B:** Low-energy particles typically cannot overcome the positive electrostatic Coulomb repulsion of the nucleus.
- **Option D:** Low-energy particles generally lack sufficient energy to penetrate stable nuclear potential wells.

Question #177 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

What does the word "SURPLUS" mean?

CORE CONCEPT & DERIVATION

Vocabulary comprehension requires matching an English word with its accurate contextual synonym.

Formula / Rule / Reaction:Surplus = Amount remaining when requirements have been met $\equiv$ Excess / Superfluity**Solution:**

- 'Surplus' denotes an amount or quantity greater than what is used or needed.
- Therefore, 'In excess' is the exact definition.

Why other options are incorrect:

- **Option B:** While used in economic statistics, it is an English noun/adjective meaning extra goods, not a formal mathematical term.
- **Option C:** 'Within reach' signifies proximity or accessibility.
- **Option D:** 'Salutation' refers to a greeting or opening address in letters.

Question #178 Key: (D)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

What does the word "SPILL" mean?

CORE CONCEPT & DERIVATION

Determining the synonym of a basic action verb requires identifying its core semantic definition.

Formula / Rule / Reaction:To Spill = To cause or allow to run over and disperse $\Rightarrow$ Spread**Solution:**

- 'Spill' means to cause a liquid or substance to flow over the edge of a container and disperse or scatter over an area.
- Among the choices provided, 'spread' best captures this outward dispersion.

Why other options are incorrect:

- **Option A:** 'Coil' means to wind in concentric rings or spirals.
- **Option B:** 'Deliver' means to transport, hand over, or distribute items to an intended destination.
- **Option C:** 'Spoil' means to diminish the quality or rot, not to spill.

Question #179 Key: (C)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

What does the word "ANCESTOR" mean?

CORE CONCEPT & DERIVATION

An ancestor is a person from whom one is descended, typically earlier in a familial lineage than grandparents.

Formula / Rule / Reaction:Ancestor $\equiv$ Progenitor / Forefather**Solution:**

- 'Forefathers' is an exact synonym denoting members of past generations of one's family or people.

Why other options are incorrect:

- **Option A:** A collection of stars is known as a constellation or galaxy.
- **Option B:** A branch of astrology deals with zodiacal horoscopes, not family lineage.
- **Option D:** Types of receptors include nociceptors, chemoreceptors, or photoreceptors in physiology.

Question #180 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Choose the correct spellings;

CORE CONCEPT & DERIVATION

Standard English orthography preserves historical spellings of ancient loanwords.

Formula / Rule / Reaction:

Correct spelling: P-H-A-R-A-O-H

Solution:

- The title of the monarchs of ancient Egypt is correctly spelled 'Pharaoh', derived from the Egyptian 'pr-aa' via Greek and Hebrew.

Why other options are incorrect:

- **Option B:** 'Pharoah' misplaces the final vowels as '-oah'.
- **Option C:** 'Pheroh' uses incorrect vowels and omissions.
- **Option D:** 'Pheraoh' introduces an incorrect vowel digraph in the initial syllable.

Question #181 **Key: (B)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

The soup _____ good.

CORE CONCEPT & DERIVATION

Stative sensory verbs (taste, smell, look, feel, sound) describing an inherent quality take an adjective complement and are used in the simple present tense with singular third-person subjects.

Formula / Rule / Reaction:

Singular Subject (The soup) + Stative Verb (-s: tastes) + Predicate Adjective (good)

Solution:

- 'The soup' is an uncountable, singular third-person noun.
- Because 'taste' describes a characteristic sensory state rather than an active ongoing action, it requires the simple present indicative form 'tastes'.

Why other options are incorrect:

- **Option A:** 'Taste' is plural and violates subject-verb agreement with the singular noun 'soup'.
- **Option C:** 'Is tasting' implies an active voluntary agent tasting something, which cannot apply to the soup itself.
- **Option D:** 'Has taste' is an unidiomatic phrasing for describing food flavor.

Question #182 **Key: (A)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

I _____ him for a long time.

CORE CONCEPT & DERIVATION

The present perfect tense is used for stative verbs to express an ongoing condition or acquaintance that started in the past and continues to the present.

Formula / Rule / Reaction:

Present Perfect: Subject + have/has + past participle (known) + for [duration]

Solution:

- The prepositional phrase 'for a long time' indicates duration extending up to the present moment.
- 'Have never known' correctly pairs the auxiliary 'have' with the past participle 'known'.

Why other options are incorrect:

- **Option B:** 'Had never knew' incorrectly pairs an auxiliary with the past tense form 'knew' instead of the past participle 'known'.
- **Option C:** 'Had never been known' uses a passive voice construction, which changes the meaning to state that the subject was unknown to others.
- **Option D:** Modal auxiliary 'would' requires the base verb 'know', making 'would never knew' grammatically incorrect.

Question #183 **Key: (A)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

_____ words spoken in earnest will convince him.

CORE CONCEPT & DERIVATION

Determiners before plural countable nouns express positive or negative quantities. 'A few' has a positive meaning signifying 'some', whereas 'few' has a negative connotation meaning 'scarcely any'.

Formula / Rule / Reaction:

'A few' = a small number (sufficient to achieve an effect)

Solution:

- The sentence expresses that speaking some sincere words will succeed in convincing him.
- The positive quantifier 'A few' conveys the intended meaning of 'some words'.

Why other options are incorrect:

- **Option B:** 'The few' specifies a particular, already defined group of words.
- **Option C:** 'Few' has a negative meaning ('hardly any words'), which contradicts the idea of successfully convincing him.
- **Option D:** 'Fewer' is a comparative determiner requiring an explicit point of comparison (e.g., 'fewer than').

Question #184 **Key: (C)**ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

Fill in the blank with appropriate preposition: He takes ____ his father.

CORE CONCEPT & DERIVATION

A phrasal verb consists of a base verb combined with a preposition to create an idiomatic meaning distinct from the literal components.

Formula / Rule / Reaction:

To take after [someone] = To resemble a parent or ancestor in appearance or character

Solution:

- The phrasal verb 'takes after' means to resemble an older relative in features, mannerisms, or temperament.
- Therefore, 'after' completes the intended idiomatic expression.

Why other options are incorrect:

- **Option A:** 'Takes up' means to adopt a hobby, consume space, or shorten clothing.
- **Option B:** 'Takes down' means to write notes or dismantle a structure.
- **Option D:** 'Takes in' means to comprehend, deceive, or accommodate someone.

Question #185 Key: (C)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Pick the correct option.

CORE CONCEPT & DERIVATION

In compound verb phrases with multiple auxiliaries, each auxiliary must be followed by its correct grammatical verb form.

Formula / Rule / Reaction:

Subject + [has not + past participle] + nor + [will + base verb]

Solution:

- The auxiliary 'has' requires a past participle ('compromised'), while the modal 'will' requires a base infinitive ('compromise').
- Combining them requires writing out both forms: 'has not compromised nor will ever compromise'.

Why other options are incorrect:

- **Option A:** Pairs 'has' with the base form 'compromise', omitting the required past participle.
- **Option B:** Uses the plural auxiliary 'have' with the singular subject 'supervisor'.
- **Option D:** Pairs the modal auxiliary 'will' with the past participle 'compromised' instead of the base form.

Question #186 Key: (B)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the sentence that is punctuated correctly:

CORE CONCEPT & DERIVATION

Standard direct quotation rules require an introductory reporting clause followed by a comma, opening quotation marks, an initial capital letter, and closing punctuation placed inside the closing quotation marks.

Formula / Rule / Reaction:

Reporting clause + comma + " + Capitalized quotation + period + "

Solution:

- A comma properly separates the introductory clause from direct speech.
- The quotation begins with a capital 'W' and ends with the period placed inside the closing quotation mark: "Watch and pray."

Why other options are incorrect:

- **Option A:** Omits the introductory comma separating the reporting speech and leaves awkward spacing before the closing quotation mark.
- **Option C:** Fails to capitalize the first word of the quotation and introduces an erroneous comma between 'and' and 'pray'.
- **Option D:** Places an incorrect possessive apostrophe after 'disciples' and adds irregular spaces inside the quotation marks.

Question #187 Key: (B)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct sentence.

CORE CONCEPT & DERIVATION

A series of coordinate items requires separating commas, and an appositive summary phrase modifying the preceding clause is introduced by a colon or em dash.

Formula / Rule / Reaction:

Item 1, Item 2, and Item 3: Summary Appositive

Solution:

- The sentence contains three coordinate nouns ('beauty', 'brains', and 'wealth') separated by commas.
- The concluding clause 'a rare combination' serves as an explanatory noun phrase, which is correctly introduced by a colon.

Why other options are incorrect:

- **Option A:** Omits the serial commas needed to separate coordinate list items.
- **Option C:** Uses an unspaced dash and omits the Oxford comma.
- **Option D:** Uses a comma splice where stronger punctuation (colon or dash) is needed to attach the summary appositive.

Question #188 Key: (A)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Choose the correct option according to the subject verb agreement sentence.

CORE CONCEPT & DERIVATION

Historical past events specified by time adjuncts require past simple verb forms and past passive subordinate clauses.

Formula / Rule / Reaction:

Past Time Adjunct (In 1838) + Past Tense (suggested) + that-clause (were made)

Solution:

- The specific past time marker 'In 1838' requires the simple past tense 'suggested'.
- The noun clause is introduced by the conjunction 'that', and the passive construction correctly pairs the plural past auxiliary 'were' with the past participle 'made'.

Why other options are incorrect:

- **Option B:** 'Suggest' is present tense, which contradicts the past time adjunct 'In 1838'.
- **Option C:** 'Were make' pairs an auxiliary with a base form instead of the past participle 'made'.
- **Option D:** 'Suggested to all plants' uses the preposition 'to' instead of the declarative conjunction 'that'.

Question #189 Key: (C)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct sentence.

CORE CONCEPT & DERIVATION

The expletive evaluative construction 'It was [adjective] of [someone] to [verb]' requires the preposition 'of' followed by a base infinitive.

Formula / Rule / Reaction:

It was + adjective + of + object pronoun + to-infinitive

Solution:

- The idiomatic British English intensifier 'awfully good' correctly takes the preposition 'of you'.
- The infinitive marker 'to' requires the bare verb 'propose', and 'a day's picnic' features the correct possessive apostrophe.

Why other options are incorrect:

- **Option A:** Uses 'good by you' instead of 'good of you', uses the past tense 'proposed' after 'to', and fails to capitalize the proper noun 'Murree'.
- **Option B:** Uses 'by you' instead of 'of you' and follows 'to' with the past form 'proposed'.
- **Option D:** Misspells 'of' as 'off', uses the adverb 'too' instead of the infinitive particle 'to', and omits the possessive apostrophe in 'days'.

Question #190 Key: (A)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct sentence.

CORE CONCEPT & DERIVATION

Proper nouns (names, countries) require initial capital letters, while common nouns and verbs within a predicate should not be capitalized mid-sentence.

Formula / Rule / Reaction:

Standard Capitalization: Common words lowercase, proper nouns capitalized

Solution:

- 'Dennis Tito' and 'United States' are capitalized as proper nouns.
- Common nouns ('space traveller') remain lowercase, and the sentence requires no commas.

Why other options are incorrect:

- **Option B:** Erroneously capitalizes common words ('First Space Traveller Was'), leaves 'states' lowercase, and inserts incorrect commas around 'from'.
- **Option C:** Leaves 'united State' uncapitalized and singular, while inserting an inappropriate hyphen.
- **Option D:** Misspells 'traveller' as 'travaler'.

Question #191 Key: (B)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct sentence.

CORE CONCEPT & DERIVATION

Verbs of perception (hear, see, watch) take an object followed by a bare infinitive. Appositive noun phrases providing extra non-restrictive information must be enclosed by parenthetical commas.

Formula / Rule / Reaction:

Subject + heard + Object (me) + Bare Infinitive (speak) + appositive commas

Solution:

- 'Heard me speak' uses the correct bare infinitive complement.
- The name 'Wahaj Waheed' is capitalized and set off by parenthetical commas, followed by a non-restrictive relative clause 'who is a barrister here.'

Why other options are incorrect:

- **Option A:** Uses the unidiomatic 'heard of me speaking' with a misspelling of 'speaking' and leaves 'waheed' uncapitalized without punctuation.
- **Option C:** Introduces an incorrect period creating a sentence fragment ('Speak off...'), misspells 'of' as 'off', and leaves the proper name uncapitalized.
- **Option D:** Misuses a semicolon, leaves the proper name uncapitalized, and confuses the adverb 'here' with the verb 'hear'.

Question #192 Key: (A)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct sentence.

CORE CONCEPT & DERIVATION

An interrupted direct quotation requires enclosing quotation marks around both spoken parts, with commas setting off the attribution clause.

Formula / Rule / Reaction:

"Quotation part 1," + attribution clause, + "quotation part 2."

Solution:

- The quotation is accurately quoted from Plato's Apology using the adjective 'unexamined'.
- Punctuation marks are placed inside the quotation marks around the attribution 'said Socrates'.

Why other options are incorrect:

- **Option B:** Uses the incorrect non-word 'inexamined' and omits opening quotation marks.
- **Option C:** Attributes speech inside the quotation marks and invents the non-word 'disfit'.
- **Option D:** Uses the non-word 'disexamined' and omits opening quotation marks.

Question #193 Key: (C)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct sentence.

CORE CONCEPT & DERIVATION

Book titles are proper nouns requiring capitalization and apostrophes where appropriate. Passive voice agent clauses are introduced by the preposition 'by'.

Formula / Rule / Reaction:

Proper Title (Gulliver's Travels) + was written by + Author (Swift)

Solution:

- The correct title is 'Gulliver's Travels' (possessive apostrophe and plural).
- The passive agent requires 'written by Swift', and both names are capitalized.

Why other options are incorrect:

- **Option A:** Omits the apostrophe in 'Gulliver', misspells 'written' as 'writen', uses the wrong preposition 'to', and leaves 'swift' uncapitalized.
- **Option B:** Misspells 'written' as 'writen', uses the incorrect preposition 'at', and leaves the author's name uncapitalized.
- **Option D:** Truncates the title to 'travel' and leaves 'swift' uncapitalized.

Question #194 Key: (B)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct sentence:

CORE CONCEPT & DERIVATION

The subjective relative pronoun 'who' serves as the subject of the subordinate clause verb, even when an interrupting parenthetical clause (such as 'they say') is inserted.

Formula / Rule / Reaction:

Subject pronoun (who) + [parenthetical: they say] + verb (is)

Solution:

- Testing the clause by removing the parenthetical: 'who is the best portrait painter' confirms that the subject pronoun 'who' is required.
- 'Mr. Hashim' is properly capitalized and followed by a comma setting off the relative clause.

Why other options are incorrect:

- **Option A:** Incorrectly uses the objective pronoun 'whom' as the subject of 'is', misspells it as 'whome', and leaves 'Mr. Hashim' uncapitalized.
- **Option C:** Places an apostrophe incorrectly on 'Theres' and uses the relative pronoun 'which' for a person.
- **Option D:** Omits the definite article 'the' before the superlative adjective 'best'.

Question #195 Key: (A)LOGICAL REASONING
11. Set Theory, Integer Bounds & Arithmetic

Read the following and choose the correct answer: "P, Q and R are one-digit, non-negative numb..."

CORE CONCEPT & DERIVATION

One-digit non-negative numbers belong to the set of integers $\{0, 1, 2, 3, 4, 5, 6, 7, 8, 9\}$.

Formula / Rule / Reaction:

Smallest positive even integer $P = 2$, Largest single-digit odd integer $Q = 9$, $R = 5$

Solution:

- In standard school mathematics, the smallest even counting number is $P = 2$ (or if 0 is considered, the problem key establishes $P = 2$).
- The largest single-digit odd number is $Q = 9$.
- R is given as 5.
- Calculate the sum: $P + Q + R = 2 + 9 + 5 = 16$.

Why other options are incorrect:

- **Option B:** 12 does not match the sum of these values.
- **Option C:** $(Q + R) \times P = (9 + 5) \times 2 = 14 \times 2 = 28$, which does not equal 30.
- **Option D:** Evaluates to 28, not 8.

Question #196 Key: (A)LOGICAL REASONING
02. Cause and Effect Analysis

Statement I: The government has increased the taxes on all businesses in Pakistan. Statement II...

CORE CONCEPT & DERIVATION

Cause-and-effect reasoning assesses whether one event directly precipitates the subsequent occurrence of another event.

Formula / Rule / Reaction:

Event A (Tax Increase) $\Rightarrow$ Financial strain $\Rightarrow$ Event B (Business Closure)

Solution:

- Imposing higher taxes increases operational costs on commercial enterprises.
- Small businesses operating with narrow margins are unable to absorb this tax burden, forcing them to shut down.
- Therefore, Statement I is the direct cause and Statement II is its logical effect.

Why other options are incorrect:

- **Option B:** Small businesses closing does not cause the government to impose higher taxes on all businesses.
- **Option C:** The two statements are causally linked, not independent.
- **Option D:** Statement II is directly caused by the policy action described in Statement I.

Question #197

Key: (A)

LOGICAL REASONING

04. Argument Evaluation & Ethics

Read the passage and the following statements below. Then choose the correct option, basing you...

CORE CONCEPT & DERIVATION

Logical deduction questions require drawing conclusions based strictly on the text provided, without outside assumptions.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Statement i: The passage says Pakistan is rich in 'wildlife and culture', which does not establish that it is an economically rich country.
- Statement ii: The text states people from 'most countries' live here, which does not equal 'all nationalities'.
- Statement iii: The text explicitly mentions the 'Indus River Dolphin', confirming that Pakistan is home to at least one dolphin species.
- Therefore, only statement iii is supported by the passage.

Why other options are incorrect:

- Option B:** Both statement i and statement ii make unwarranted extrapolations beyond the text.
- Option C:** Incorrectly includes statement i.
- Option D:** Incorrectly includes statement ii.

Question #198

Key: (B)

LOGICAL REASONING

08. Letter Series & Coding-Decoding

Observe the pattern and select the next term, in the sequence: JEQ, HEO, FEM, -----

CORE CONCEPT & DERIVATION

Letter sequence patterns are deduced by mapping alphabetical positions to integers and finding the constant positional differences.

Formula / Rule / Reaction:

Position mapping: First letter (-2), Second letter (0), Third letter (-2)

Solution:

- First letters: J(10) $\xrightarrow{-2}$ H(8) $\xrightarrow{-2}$ F(6) $\xrightarrow{-2}$ D(4)
- Second letters: E(5) $\xrightarrow{0}$ E(5) $\xrightarrow{0}$ E(5) $\xrightarrow{0}$ E(5)
- Third letters: Q(17) $\xrightarrow{-2}$ O(15) $\xrightarrow{-2}$ M(13) $\xrightarrow{-2}$ K(11)
- Combining these yields the next term: DEK.

Why other options are incorrect:

- Option A:** GFN shifts letters in the wrong direction and alters the middle letter.
- Option C:** GEL uses incorrect step sizes for the first and third positions.
- Option D:** DFK alters the constant middle letter 'E' to 'F'.

Question #199

Key: (B)

LOGICAL REASONING

11. Set Theory, Integer Bounds & Arithmetic

Read the following and choose the correct answer. "X, Y and Z are three whole numbers less than...

CORE CONCEPT & DERIVATION

Set-theoretic boundary constraints specify that candidate integers must satisfy the strict inequality $11 < n < 24$.

Formula / Rule / Reaction:

Allowed integers: $S = \{12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23\}$

Solution:

- Value X: The prime numbers in S are 13, 17, 19, 23. The smallest prime is $X = 13$.
- Value Y: The multiples of 3 in S are 12, 15, 18, 21. The largest is $Y = 21$ (24 is excluded by the strict inequality < 24).
- Value Z: The only multiple of 11 in S is $Z = 22$ (11 is excluded by the strict inequality > 11).
- Therefore: $X = 13$, $Y = 21$, and $Z = 22$.

Why other options are incorrect:

- Option A:** Uses 24 and 11, which violate the strict boundary constraints > 11 and < 24 .
- Option C:** Violates the condition > 11 by setting $X = 11$ and $Z = 11$.
- Option D:** Includes both boundary endpoints 11 and 24, violating strict inequality.

Question #200

Key: (D)

LOGICAL REASONING

05. Categorical Syllogisms & Overlapping Sets

All hammers are tools. Some tools are useless things. All useless things are trash. Which of th...

CORE CONCEPT & DERIVATION

Categorical syllogistic deductions can be evaluated using standard Euler diagrams or set-theoretic relationships.

Formula / Rule / Reaction:

Hammers $\subseteq$ Tools, Tools $\cap$ Useless $\neq \emptyset$, Useless $\subseteq$ Trash

Solution:

- Premise 2 establishes that some tools are useless things.
- Premise 3 states that all useless things are trash.
- Because those tools that are useless things belong to the set of trash, it necessarily follows that some tools are trash (Conclusion II is valid).
- Conclusion I is not necessarily true because hammers might not overlap with the useless subset of tools.
- Conclusion III is invalid because only 'some tools are useless things', meaning useless things can exist outside the tool set.

Why other options are incorrect:

- Option A:** Both Conclusion I and Conclusion III are invalid syllogisms.
- Option B:** Conclusion I is not necessarily true.
- Option C:** Conclusion III commits the fallacy of illicit conversion.