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BUMHS QUETTA

BUMHS Quetta MDCAT 2022 Official Paper

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

- 📌 Official Admitting Board: Bolan University of Medical and Health Sciences Quetta 🎯 Archive Code: BEAMBE-FLP-BUMHS-2022
- 🕒 Duration: 200 Minutes (3h 20m)

200

TOTAL QUESTIONS

200m

OFFICIAL DURATION

+1 / 0.00

ZERO NEGATIVE MARKING

200

MAXIMUM MARKS

📄 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

BIO SECTION: BIOLOGY

Questions 1 to 68 (68 MCQs)

Q1. BIO

Diastase (amylase) acts on which of the following substrates?

- (A) Maltose
- (B) Sucrose
- (C) Lactose
- (D) Starch

Q2. BIO

Which of the following processes is antagonistic to condensation?

- (A) Decarboxylation
- (B) Hydration
- (C) Dehydration
- (D) Hydrolysis

Q3. BIO

Which statement is wrong about saturated fats?

- (A) They have multiple double bonds in the carbon chains of their fatty acids
- (B) They are more common in animals than in plants
- (C) They contain more hydrogen than unsaturated fats having the same number of carbon atoms
- (D) They generally solidify at room temperature

Q4. BIO

Which of the following is classified as a connective tissue?

- (A) Cartilage
- (B) Epithelium
- (C) Muscle
- (D) Nerve

Q5. BIO

A virion is designated as which of the following?

- (A) Viral enzyme
- (B) Viral genome
- (C) Complete virus particle
- (D) Viral lysosome

Q6. BIO

A cell without a cell wall will burst when placed in which of the following?

- (A) Hypotonic solution
- (B) Hypertonic solution
- (C) Isotonic solution
- (D) Solution having more electrolytes

Q7. BIO

Long term physiological controls such as rate of growth and sexual maturity are regulated by:

- (A) Neurons
- (B) Hormones
- (C) Glands
- (D) Hypothalamus

Q8. BIO

In which human blood group are both A and B antigens present on erythrocytes?

- (A) Blood group A
- (B) Blood group B
- (C) Blood group AB
- (D) Blood group O

Q9. BIO

Facilitated diffusion involves carrier molecules. Chemically, these carriers are:

- (A) Glycolipids
- (B) Lipids
- (C) Proteins
- (D) Carbohydrates

Q10. BIO

Who proposed the fluid mosaic model of the plasma membrane?

- (A) Lorenz Oken and Brown
- (B) Robert Brown and Palade
- (C) Singer and Nicolson
- (D) Singer and De-Duve

Q11. BIO

Which of the following represents the two simplest amino acids?

- (A) Trypsin and glycine
- (B) Trypsin and alanine
- (C) Glycine and alanine
- (D) Glutamate and alanine

Q12. BIO

Which of the following animals does not have a soft, unsegmented body typical of molluscs?

- (A) Hirudo
- (B) Unio
- (C) Sepia
- (D) Loligo

Q13. BIO

The stage of the menstrual cycle that begins immediately after ovulation is:

- (A) Menstrual stage
- (B) Follicular stage
- (C) Proliferative stage
- (D) Secretory stage

Q14. BIO

Animals characterized by jointed appendages and a chitinous exoskeleton belong to phylum:

- (A) Chordata
- (B) Arthropoda
- (C) Annelida
- (D) Mollusca

Q15. BIO

Similarity in the molecular structure and genetic mechanism of DNA and RNA provides evidence that all organisms are:

- (A) Heterophyletic
- (B) Monophyletic
- (C) Paraphyletic
- (D) Polyphyletic

Q16. BIO

Which viruses are designated as naked viruses?

- (A) Non-enveloped viruses
- (B) Enveloped viruses
- (C) Prions
- (D) Viroids

Q17. BIO

Maltose is classified as a:

- (A) Polysaccharide
- (B) Disaccharide
- (C) Oligosaccharide
- (D) Monosaccharide

Q18. BIO

Lingual lipase is secreted by which of the following glands?

- (A) Parotid gland
- (B) Submandibular gland
- (C) Ebner's glands
- (D) Pancreas

Q19. BIO

Which structural protein forms the primary organic matrix of bone and cartilage?

- (A) Myoglobin
- (B) Hemoglobin
- (C) Fibrinogen
- (D) Collagen

Q20. BIO

How many distinct phenotypes are possible in the human ABO blood group system?

- (A) 2
- (B) 4
- (C) 6
- (D) 8

Q21. BIO

Histamine released during allergic or inflammatory reactions causes blood vessels to:

- (A) Dilate
- (B) Constrict
- (C) Block
- (D) Rupture

Q22. BIO

Which of the following functions is characteristic of the smooth endoplasmic reticulum?

- (A) Involved in removal of storage and waste products
- (B) Involved in transmission of impulses
- (C) Involved in protein metabolism
- (D) Involved in intracellular digestion

Q23. BIO

Maximum photosynthetic rate occurs when a plant is illuminated with:

- (A) Red light
- (B) Green light
- (C) Yellow light
- (D) Blue light

Q24. BIO

Which of the following prokaryotic microorganisms naturally lacks a peptidoglycan cell wall?

- (A) Archaeobacteria
- (B) Cyanobacteria
- (C) Eubacteria
- (D) Mycoplasma

Q25. BIO

Poliovirus is an example of which morphological class of viruses?

- (A) Spherical (icosahedral) viruses
- (B) Tadpole-shaped viruses
- (C) Rod-shaped viruses
- (D) Helical viruses

Q26. BIO

The average normal human sperm count per milliliter of semen is:

- (A) 20 to 150 million
- (B) 2 to 10 million
- (C) 20 to 150 thousand
- (D) 2 to 10 thousand

Q27. BIO

When and by whom was the Golgi apparatus discovered?

- (A) 1888, Camillo Golgi
- (B) 1898, Camillo Golgi
- (C) 1988, George Golgi
- (D) 1998, Kamillo Golgi

Q28. BIO

Which of the following is classified as a DNA virus?

- (A) Poliovirus
- (B) Influenza virus
- (C) Herpes virus
- (D) Mumps virus

Q29. BIO

The temperature at which a cold-inactivated enzyme regains its catalytic activity is known as:

- (A) Optimum temperature
- (B) Maximum temperature
- (C) Minimum temperature
- (D) Favorable temperature

Q30. BIO

The optimum pH for digestive enzymes of the stomach (such as pepsin) is:

- (A) Highly acidic
- (B) Highly alkaline
- (C) Slightly acidic
- (D) Slightly alkaline

Q31. BIO

Pseudomonas is an ecologically important example of which nutritional type of bacteria?

- (A) Photoautotrophic bacteria
- (B) Saprophytic bacteria
- (C) Symbiotic bacteria
- (D) Parasitic bacteria

Q32. BIO

Which of the following respiratory processes is utilized by yeast in baking?

- (A) Aerobic respiration
- (B) External respiration
- (C) Internal respiration
- (D) Anaerobic respiration

Q33. BIO

Treponema pallidum is the causative organism of which disease?

- (A) Gonorrhea
- (B) Syphilis
- (C) AIDS
- (D) Diabetes

Q34. BIO

When two or more independent genes interact so that each dominant allele contributes additively to a single phenotype, the inheritance pattern is:

- (A) Codominance
- (B) Polygenic inheritance
- (C) Epistasis
- (D) Incomplete dominance

Q35. BIO

A diploid chromosome number of 14 ($2n = 14$) is found in:

- (A) Potato
- (B) Fruit fly
- (C) Garden pea
- (D) Rat

Q36. BIO

In human anatomy, the trachea lies in which anatomical position relative to the esophagus?

- (A) Dorsal
- (B) Ventral
- (C) Medial
- (D) Lateral

Q37. BIO

A hemophiliac male marries a hemophilia carrier female and they have 4 children (1 affected, 3 unaffected). What is the probability that their next child will be hemophiliac?

- (A) 0.25
- (B) 0.50
- (C) 0.75
- (D) 1.00

Q38. BIO

Which of the following cell types does not possess a Golgi apparatus?

- (A) Bacterial cell
- (B) Animal cell
- (C) Plant cell
- (D) Fungal cell

Q39. BIO

The corpus luteum primarily secretes which hormone?

- (A) Parathormone
- (B) Oxytocin
- (C) Progesterone
- (D) Testosterone

Q40. BIO

The maximum water potential (Ψ_w) of pure water at standard temperature and atmospheric pressure is:

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

Q41. BIO

What is the scientific study of joints called?

- (A) Arthralgia
- (B) Arthrology
- (C) Myology
- (D) Cytology

Q42. BIO

Which of the following organs functions as a major secondary lymphatic organ?

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

Q43. BIO

Which statement is true regarding the nuclear envelope and its pores?

- (A) The number of nuclear pores is highly variable depending on cell activity
- (B) The number of nuclear pores is highly constant in all cells
- (C) It is a single-membrane structure
- (D) The outer membrane is continuous with the Golgi complex

Q44. BIO

The BCG (Bacillus Calmette–Guerin) vaccine is administered to provide immunity against:

- (A) Pulmonary tuberculosis
- (B) Typhoid
- (C) Cholera
- (D) Pneumonia

Q45. BIO

Mitochondria are concentrated in which anatomical part of a human sperm?

- (A) Acrosome
- (B) Head
- (C) Mid-piece
- (D) Tail

Q46. BIO

Which of the following is not an example of the anatomical reduction or disuse of organs?

- (A) Loss of snake legs
- (B) Shedding of milk teeth
- (C) Muscle atrophy
- (D) Vestigial ear muscles

Q47. BIO

Cyanide acts as which type of enzyme inhibitor?

- (A) Competitive inhibitor
- (B) Non-competitive inhibitor
- (C) Co-enzyme
- (D) Activator

Q48. BIO

Which of the following forms of life first evolved approximately 1.5 billion years ago?

- (A) Prokaryotes
- (B) Animals
- (C) Eukaryotes
- (D) Seed plants

Q49. BIO

Dominance describes the physiological effect of an allele over its partner allele occupying the:

- (A) Same locus on the same chromosome
- (B) Different locus on the same chromosome
- (C) Same locus on the respective homologue
- (D) Different locus on the respective homologue

Q50. BIO

During an involuntary reflex, the nerve impulse travels along a fixed pathway known as the:

- (A) Reflex action of nerve impulse
- (B) Reflex action of glands
- (C) Reflex arc and reflex action
- (D) Reflex arc

Q51. BIO

Which of the following can be considered as metabolic waste products of bacteria?

- (A) Alcohol, acetic acid, and lactic acid
- (B) Alcohol, potassium, and sulphur
- (C) Alcohol, glycogen, and phosphate
- (D) Glycogen, fat, and potassium

Q52. BIO

Most of the carbon dioxide in human blood is transported in which of the following forms?

- (A) Carboxyhemoglobin
- (B) Carbaminohemoglobin
- (C) Bicarbonate ions
- (D) Dissolved gas in plasma

Q53. BIO

Who proposed the evolutionary concept of the unity of life through common descent?

- (A) Aristotle
- (B) Lamarck
- (C) Darwin
- (D) Alfred Russel Wallace

Q54. BIO

What is the number of hydrogen atoms in the molecular formula of Chlorophyll-a?

- (A) Six
- (B) Fifty-five
- (C) Seventy
- (D) Seventy-two

Q55. BIO

Alternation of generations (metagenesis) between polyp and medusa body forms is characteristic of:

- (A) Annelida
- (B) Arthropoda
- (C) Coelenterata (Cnidaria)
- (D) Echinodermata

Q56. BIO

Which bacteria are ecologically designated as the primary scavengers and decomposers of the Earth?

- (A) Parasitic bacteria
- (B) Saprophytic bacteria
- (C) Symbiotic bacteria
- (D) Photosynthetic bacteria

Q57. BIO

Lysosomes were named based on which of the following criteria?

- (A) Size and shape
- (B) Shape and structure
- (C) Structure and role
- (D) Composition and role

Q58. BIO

White matter in the central nervous system is predominantly composed of:

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

Q59. BIO

The catalytic active site of an enzyme is directly composed of how many amino acid residues?

- (A) 3 to 12
- (B) 30 to 50
- (C) 50 to 100
- (D) 100 to 1000

Q60. BIO

The hormone that makes the endometrium receptive for the implantation of a blastocyst is:

- (A) Follicle-Stimulating Hormone (FSH)
- (B) Estrogen
- (C) Progesterone
- (D) Luteinizing Hormone (LH)

Q61. BIO

Acromegaly is an endocrine disorder caused by hypersecretion of which hormone in adults?

- (A) STH (Somatotrophic Hormone / Growth Hormone)
- (B) TSH (Thyroid Stimulating Hormone)
- (C) ICSH (Interstitial Cell Stimulating Hormone)
- (D) FSH (Follicle Stimulating Hormone)

Q62. BIO

Glycoproteins function as cell surface markers in which of the following biological structures?

- (A) ABO blood group antigens
- (B) Chloroplast thylakoid membrane
- (C) Egg yolk vitelline membrane
- (D) Myelin sheath of nerves

Q63. BIO

An open circulatory system with a hemocoel is found in which of the following organisms?

- Ⓐ Earthworm
- Ⓑ Cockroach
- Ⓒ Human
- Ⓓ Fish

Q64. BIO

During skeletal muscle contraction, the troponin complex binds directly to all of the following EXCEPT:

- Ⓐ Actin
- Ⓑ Tropomyosin
- Ⓒ Myosin
- Ⓓ Calcium ions

Q65. BIO

Red blood cells of blood group A-negative can be safely transfused to a recipient with which blood type?

- Ⓐ O-negative
- Ⓑ O-positive
- Ⓒ A-positive
- Ⓓ B-positive

Q66. BIO

Oxygen, which serves as the terminal electron acceptor in the mitochondrial electron transport chain, is characterized as being:

- Ⓐ At a high free energy level
- Ⓑ Chemically unreactive
- Ⓒ At a low free energy level
- Ⓓ Deactivated upon accepting electrons

Q67. BIO

Sensory receptors specialized for the detection of noxious or painful stimuli are known as:

- Ⓐ Thermoreceptors
- Ⓑ Chemoreceptors
- Ⓒ Nociceptors
- Ⓓ Photoreceptors

Q68. BIO

Cardiac muscle tissue is found exclusively in which of the following anatomical structures?

- Ⓐ Heart walls only
- Ⓑ Heart wall and aorta
- Ⓒ Heart wall and atrioventricular valves
- Ⓓ Heart wall and pulmonary artery

CHEM SECTION: CHEMISTRY

Questions 69 to 122 (54 MCQs)

Q69. CHEM

Which of the following statements regarding the chemical properties of phenol is correct?

- (A) Phenol is less acidic than aliphatic alcohols
- (B) Phenol is more acidic than hydrochloric acid
- (C) Phenol dissolves alkalis readily
- (D) Phenol is more acidic than carboxylic acids

Q70. CHEM

Precipitation of an ionic solute occurs from solution when the ionic product (Q_{sp}) is:

- (A) Less than K_{sp}
- (B) Greater than K_{sp}
- (C) Equal to K_{sp}
- (D) Independent of K_{sp}

Q71. CHEM

What is the systematic IUPAC name of the hydrocarbon $\text{CH}_3\text{--CH}_2\text{--CH}=\text{CH--CH}_2\text{--CH}=\text{CH--CH}_3$?

- (A) 2,3-octadiene
- (B) 2,4-octadiene
- (C) 2,5-octadiene
- (D) 2,5-octadyne

Q72. CHEM

Which of the following statements is conceptually correct concerning the Avogadro constant (N_A)?

- (A) It is the mass of one mole of any element
- (B) It is the mass of 6.023×10^{23} atoms of any element
- (C) It is the number of atoms in one mole of neon
- (D) It is the number of atoms in 12 g of any element

Q73. CHEM

Which of the following halogenated alkanes can exist as an optically inactive meso stereoisomer?

- (A) 2-chlorobutane
- (B) 2,3-dichloropentane
- (C) 2,3-dichlorobutane
- (D) 1,2-dichlorobutane

Q74. CHEM

Select the periodic group whose elements lose valence electrons most readily to form cations:

- (A) Group IA
- (B) Group VA
- (C) Group VIA
- (D) Group VIIA

Q75. CHEM

The coupling reaction between an alkyl halide and a lithium dialkylcuprate reagent yields:

- (A) Alkane
- (B) Alkene
- (C) Alkyl copper
- (D) Alkenyl halide

Q76. CHEM

Which pair of transition metal cations both possess exactly five unpaired d-electrons in their high-spin ground states?

- (A) Fe^{2+} and Mn^{2+}
- (B) Fe^{2+} and Mn^{3+}
- (C) Fe^{3+} and Mn^{3+}
- (D) Fe^{3+} and Mn^{2+}

Q77. CHEM

If four identical balloons are filled with different pure gases at the same temperature and pressure, which balloon will deflate first through microscopic pores?

- (A) Helium
- (B) Oxygen
- (C) Hydrogen
- (D) Nitrogen

Q78. CHEM

Which of the following chemical elements has the lowest first ionization potential?

- (A) He
- (B) Li
- (C) Zn
- (D) N

Q79. CHEM

Which atomic concept was originally formulated and introduced by Niels Bohr?

- (A) Quantized energy levels
- (B) Wave-mechanical orbitals
- (C) Sub-orbits
- (D) Magnetic quantum numbers

Q80. CHEM

Which enzyme is clinically administered for the therapeutic treatment of acute lymphoblastic leukemia (blood cancer) in children?

- (A) Thrombin
- (B) L-asparaginase
- (C) LDH-1 (Lactate Dehydrogenase)
- (D) Zymase

Q81. CHEM

The ideal gas equation ($PV = nRT$) can be rearranged to calculate all of the following gas properties EXCEPT:

- (A) Pressure
- (B) Density
- (C) Number of moles
- (D) Solution molarity

Q82. CHEM

During the electrophilic aromatic substitution of benzene with fuming sulfuric acid, the attacking active electrophile is:

- (A) SO_2
- (B) SO_3
- (C) SO_4^{2-}
- (D) H_2SO_4

Q83. CHEM

Which of the following chemical species is classified as an electrophile rather than a nucleophile?

- (A) $\text{C}_3\text{H}_7\text{O}^-$
- (B) SCN^-
- (C) H_2C^+ (or carbocations)
- (D) NH_3

Q84. CHEM

What is the systematic IUPAC name of the organic compound $\text{C}_6\text{H}_{11}\text{CHO}$?

- (A) Benzenecarbaldehyde
- (B) Cyclohexanal
- (C) Cyclohexyl aldehyde
- (D) Cyclohexanecarbaldehyde

Q85. CHEM

A solution that resists significant changes in its hydrogen ion concentration (pH) upon the addition of small amounts of acid or base is called a:

- (A) Acidic solution
- (B) Buffer solution
- (C) Basic solution
- (D) Supersaturated solution

Q86. CHEM

What is the ground-state electronic configuration of a neutral Carbon atom ($Z = 6$)?

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

Q87. CHEM

Phenol undergoes electrophilic aromatic substitution much faster than benzene. This enhanced reactivity is primarily due to which electronic effect of the hydroxyl group?

- (A) Intermolecular hydrogen bonding
- (B) Electron-withdrawing inductive effect
- (C) Strong electron-donating mesomeric (+M) effect
- (D) Weak electron-withdrawing mesomeric (-M) effect

Q88. CHEM

What is the correct order of decreasing reactivity of carbonyl compounds toward nucleophilic addition reactions?

- (A) Benzaldehyde > Benzophenone > Acetophenone
- (B) Benzophenone > Benzaldehyde > Acetophenone
- (C) Acetophenone > Benzaldehyde > Benzophenone
- (D) Benzaldehyde > Acetophenone > Benzophenone

Q89. CHEM

The general valence shell electronic configuration of the d-block transition elements is represented by:

- (A) $(n-1)d^{1-10}ns^2$
- (B) $(n-1)d^{1-10}(n-1)s^{0-2}$
- (C) $(n-1)d^{1-10}ns^{0-2}$
- (D) $nd^{1-10}ns^{0-2}$

Q90. CHEM

On the microscopic atomic scale, atomic mass (weight) is conventionally expressed in which units?

- (A) amu (atomic mass units)
- (B) Grams
- (C) Kilograms
- (D) Moles

Q91. CHEM

What is the oxidation state of chlorine in an isolated molecule of diatomic chlorine gas (Cl_2)?

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

Q92. CHEM

A dipolar ion carrying separated positive and negative electrical charges on the same molecule is termed a(n):

- (A) Double salt
- (B) Internal salt (Zwitterion)
- (C) Basic salt
- (D) Acidic salt

Q93. CHEM

Which of the following alkali metal (Group IA) hydroxides has the lowest aqueous solubility at room temperature?

- (A) NaOH
- (B) LiOH
- (C) KOH
- (D) RbOH

Q94. CHEM

During the spontaneous formation of a stable covalent or ionic chemical bond between isolated atoms, the total potential energy of the system:

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

Q95. CHEM

In 1825, Michael Faraday first isolated and discovered benzene from the condensate of an illuminating gas obtained through the:

- (A) Destructive distillation of vegetable or fish oils
- (B) Fractional distillation of crude petroleum
- (C) Steam distillation of coal tar
- (D) Vacuum distillation of wood spirit

Q96. CHEM

What is the systematic IUPAC name of the branched alkane $\text{CH}_3-(\text{CH}_2)_3-\text{C}(\text{CH}_3)_3$?

- (A) 2-methylhexane
- (B) Neo-octane
- (C) 5,5-dimethylhexane
- (D) 2,2-dimethylhexane

Q97. CHEM

In a chemical reaction, the reactant that is completely consumed first and limits the amount of product formed is the:

- (A) Active reactant
- (B) Excess reactant
- (C) Limiting reactant
- (D) Catalytic reactant

Q98. CHEM

The spatial geometric arrangement of ligands in a coordination complex is primarily determined by the:

- (A) Number of chelating rings
- (B) Hybridization state of the central metal ion
- (C) Charge density of the counter ion
- (D) Electronegativity of the donor atom

Q99. CHEM

When magnesium metal is ignited in air, it burns with a characteristic and brilliant flame of what color?

- (A) Blue
- (B) Violet
- (C) Yellow
- (D) White

Q100. CHEM

According to the standard electrochemical series, which of the following metal cations possesses the highest (least negative) standard reduction potential (E°)?

- (A) Barium ion (Ba^{2+})
- (B) Calcium ion (Ca^{2+})
- (C) Magnesium ion (Mg^{2+})
- (D) Aluminum ion (Al^{3+})

Q101. CHEM

Why does a reversible chemical reaction not proceed to completion?

- (A) Reactants are chemically reactive
- (B) Reactants are completely stable
- (C) Products are reactive and recombine to form reactants
- (D) Products are chemically inert and stable

Q102. CHEM

Which of the following structural characteristics is true for amorphous solids?

- (A) They have a perfect long-range arrangement of constituent atoms
- (B) They possess sharp and well-defined melting points
- (C) They can possess small localized regions of orderly arranged atoms
- (D) They undergo clean cleavage along distinct planes when cut

Q103. CHEM

Which of the following functional groups is present in ethyl acetate?

- (A) Aldehyde group
- (B) Carboxyl group
- (C) Ester group
- (D) Ether group

Q104. CHEM

Which of the following organic compounds reduces Tollens' reagent to produce a metallic silver mirror?

- (A) Methanal
- (B) Acetic acid
- (C) Ethyl alcohol
- (D) Acetone

Q105. CHEM

A catalyst accelerates the rate of a chemical reaction primarily by:

- (A) Increasing the total collision frequency between reactant molecules
- (B) Increasing the proportion of molecules having kinetic energy greater than the activation energy
- (C) Increasing the enthalpy change of the reaction
- (D) Increasing the stoichiometric concentration of reactants

Q106. CHEM

Which structural isomer of pentane (C_5H_{12}) has the lowest boiling point?

- (A) n-Pentane
- (B) Isopentane
- (C) Neopentane
- (D) 2-Methylbutane

Q107. CHEM

The rate of a chemical reaction when the concentration of each reactant is taken as unity (1 mol/dm^3) is termed the:

- (A) Arrhenius frequency factor
- (B) Equilibrium constant
- (C) Molecularity of reaction
- (D) Specific rate constant (velocity constant)

Q108. CHEM

Dry heating (pyrolysis) of solid calcium acetate yields which of the following organic compounds?

- (A) Acetaldehyde
- (B) Acetic acid
- (C) Acetone
- (D) Ethane

Q109. CHEM

According to Charles's law, the theoretical volume of a given mass of an ideal gas drops to zero at what temperature?

- (A) -273°C
- (B) 273°C
- (C) 100°C
- (D) 0°C

Q110. CHEM

Lucas reagent, used to distinguish primary, secondary, and tertiary alcohols, consists of a mixture of:

- (A) $AlCl_3$ and concentrated HCl
- (B) Concentrated HCl
- (C) Anhydrous $ZnCl_2$
- (D) Both anhydrous $ZnCl_2$ and concentrated HCl

Q111. CHEM

The Born-Haber cycle represents an application of Hess's law primarily used to calculate the:

- (A) Enthalpy of combustion of hydrocarbons
- (B) Lattice energy of covalent network compounds
- (C) Lattice energy of crystalline ionic solids
- (D) Ionization energy of gaseous metal atoms

Q112. CHEM

Why must two electrons occupying the same atomic orbital possess opposite spins?

- (A) Opposite spins eliminate friction between electrons
- (B) Opposite spins double the orbital angular momentum
- (C) Opposite spins cancel electron charges completely
- (D) Opposite spins minimize electrostatic repulsion and generate opposing magnetic fields

Q113. CHEM

The dynamic viscosity of a liquid decreases significantly with an increase in which parameter?

- (A) Molecular mass
- (B) Temperature
- (C) External atmospheric pressure
- (D) Intermolecular forces of attraction

Q114. CHEM

As the value of the principal quantum number (n) increases, the radial size of an s-orbital:

- (A) Decreases
- (B) Increases
- (C) Remains unchanged
- (D) Fluctuates periodically

Q115. CHEM

Which of the following is classified as a secondary intermolecular interaction rather than a primary chemical bond?

- (A) Ionic bond
- (B) Hydrogen bond
- (C) Dative (coordinate covalent) bond
- (D) Covalent bond

Q116. CHEM

Which of the following organic compounds contains sp-hybridized carbon atoms?

- (A) Benzene
- (B) 1-Butene
- (C) 2-Butyne
- (D) 1-Pentene

Q117. CHEM

Which of the following substances is classified as an amorphous solid rather than a crystalline solid?

- Ⓐ Copper sulfate
- Ⓑ Sucrose (cane sugar)
- Ⓒ Sodium chloride
- Ⓓ Rubber

Q118. CHEM

In standard SI chemical thermodynamics, bond energy is conventionally expressed in:

- Ⓐ kJ/mol
- Ⓑ Calories
- Ⓒ Joules
- Ⓓ Volts

Q119. CHEM

The resonance hybrid structure of benzene is more stable than the hypothetical 1,3,5-cyclohexatriene structure by how many kJ/mol?

- Ⓐ 358.5 kJ/mol
- Ⓑ 208.0 kJ/mol
- Ⓒ 150.5 kJ/mol
- Ⓓ 231.5 kJ/mol

Q120. CHEM

The primary structural feature linking individual amino acid residues together in proteins is the:

- Ⓐ Peptide linkage
- Ⓑ Glycosidic linkage
- Ⓒ Ester linkage
- Ⓓ Ether linkage

Q121. CHEM

Acetic acid is a much weaker acid in aqueous solution than sulfuric acid because:

- Ⓐ It decomposes when temperature increases
- Ⓑ It has a much lower degree of ionization
- Ⓒ It contains an un-ionized carboxyl group
- Ⓓ It exhibits an electron-withdrawing inductive effect

Q122. CHEM

The conversion of a neutral gaseous sodium atom into a sodium cation is a(n):

- Ⓐ Exothermic process
- Ⓑ Endothermic process
- Ⓒ Thermally neutral process
- Ⓓ Sublimation process

PHY SECTION: PHYSICS

Questions 123 to 176 (54 MCQs)

Q123. PHY

The maximum (peak) induced electromotive force generated in an AC generator coil rotating in a uniform magnetic field does not depend on the:

- (A) Electrical resistance of the coil
- (B) Number of turns of the coil
- (C) Surface area enclosed by the coil
- (D) Rotational frequency of the coil

Q124. PHY

Which of the following electrical components is classified as an Ohmic device?

- (A) Tungsten filament bulb
- (B) Semiconductor transistor
- (C) Semiconductor p-n junction diode
- (D) Standard copper wire conductor

Q125. PHY

According to Faraday's law of induction, an electromotive force is induced in a conducting circuit whenever there is a:

- (A) Change in electric flux
- (B) Change in magnetic flux
- (C) Absence of magnetic fields
- (D) Constant, steady magnetic flux

Q126. PHY

A circuit that smooths the pulsating direct current output of a rectifier into a steady direct voltage is known as a:

- (A) Generator
- (B) Step-up transformer
- (C) Filter circuit
- (D) Inductive choke

Q127. PHY

According to the right-hand rule for rotational kinematics, the vector direction of angular displacement points along the:

- (A) Curl of fingers
- (B) Index finger
- (C) Outstretched thumb along the axis of rotation
- (D) Direction of the linear velocity

Q128. PHY

During the flight of a projectile, atmospheric air friction directly affects:

- (A) The launch angle only
- (B) The horizontal component of motion only
- (C) The vertical component of motion only
- (D) Both the horizontal and vertical components of motion

Q129. PHY

A periodic wave is fundamentally characterized by which set of three interrelated physical parameters?

- (A) Amplitude, wavelength, and acceleration
- (B) Frequency, wavelength, and acceleration
- (C) Wavelength, frequency, and wave speed
- (D) Displacement, wavelength, and wave speed

Q130. PHY

Which of the following physical experiments provides direct experimental proof of the particle nature of light?

- (A) Young's double-slit interference
- (B) Fraunhofer diffraction
- (C) Total internal reflection
- (D) Photoelectric effect

Q131. PHY

To achieve superior resolving power and sharp spectral line separation, modern spectrometers utilize a:

- (A) Capacitor bank
- (B) Diffraction grating
- (C) Mica window
- (D) Polarizer sheet

Q132. PHY

A permanent bar magnet falls vertically under gravity along the axis of a long, vertical hollow copper tube. The downward acceleration of the falling magnet inside the tube is:

- (A) Equal to g
- (B) Greater than g
- (C) Less than g
- (D) Zero throughout its fall

Q133. PHY

An electric lamp has a power rating of 20 W and operates at an efficiency of 50%. What is its useful output power?

- (A) 10 W
- (B) 15 W
- (C) 18 W
- (D) 20 W

Q134. PHY

Mechanical longitudinal waves (sound waves) propagate fastest through which state of matter?

- (A) Solids
- (B) Liquids
- (C) Gases
- (D) Plasma

Q135. PHY

The electrostatic potential at the geometric center of an isolated, uniformly charged conducting sphere is:

- (A) Zero
- (B) Less than the potential at its surface
- (C) Greater than the potential at its surface
- (D) Equal to the potential at its surface

Q136. PHY

In a radioactive decay experiment, the count rate of an isotope drops from 400 counts/second to 50 counts/second in 150 minutes. What is the half-life of this isotope?

- (A) 30 minutes
- (B) 40 minutes
- (C) 50 minutes
- (D) 60 minutes

Q137. PHY

Which of the following statements regarding magnetic attraction is true?

- (A) A magnet attracts all plastic materials
- (B) A magnet attracts any metallic element
- (C) A magnet strongly attracts ferromagnetic materials like iron and steel
- (D) A magnet strongly attracts non-magnetic metals like pure aluminum

Q138. PHY

The kinetic energy of a simple harmonic oscillator is twice its potential energy at a displacement (x) equal to what fraction of its amplitude (x_0)?

- (A) $\frac{1}{2}x_0$
- (B) $\frac{1}{\sqrt{2}}x_0$
- (C) $\frac{1}{\sqrt{3}}x_0$
- (D) $\frac{2}{3}x_0$

Q139. PHY

When a positively charged body is brought near an isolated, uncharged conducting cylinder on an insulating stand:

- (A) The nearer end acquires a positive charge while the farther end acquires a negative charge
- (B) No net charge is induced anywhere on the conductor
- (C) The nearer end acquires an opposite (negative) charge and the farther end acquires a like (positive) charge
- (D) Both ends acquire identical negative charges

Q140. PHY

The fractional change in electrical resistance per kelvin change in temperature is defined as the:

- (A) Electrical conductivity
- (B) Specific electrical resistivity
- (C) Temperature coefficient of resistivity
- (D) Temperature coefficient of resistance

Q141. PHY

A person pushes with high muscular effort against a rigid brick wall but fails to move it. The mechanical work done on the wall is:

- (A) Negative work
- (B) Positive work
- (C) No work at all (zero work)
- (D) Maximum positive work

Q142. PHY

What is the ratio of the angular speed of the minute hand to that of the hour hand of a standard mechanical watch?

- (A) 1 : 8
- (B) 6 : 1
- (C) 1 : 12
- (D) 12 : 1

Q143. PHY

Which of the following vector pairs always points in the exact same direction during linear motion?

- (A) Net force and displacement
- (B) Net force and velocity
- (C) Net force and acceleration
- (D) Velocity and acceleration

Q144. PHY

Newton's third law of motion establishes which fundamental principle regarding forces in nature?

- (A) The acceleration produced by an isolated force
- (B) The existence of an isolated single force
- (C) The existence of unbalanced resultant forces
- (D) The existence of forces in matched action-reaction pairs

Q145. PHY

Thermal equilibrium between bodies in an environment is established through the process of:

- (A) Internal heat generation
- (B) Heat dissipation into empty space
- (C) Heat flow between bodies at different temperatures
- (D) Enthalpy conservation without heat transfer

Q146. PHY

A second's pendulum begins oscillating from its extreme position. What is the ratio of its amplitude to its displacement after 7 seconds?

- (A) 1 : 2
- (B) 1 : 4
- (C) 1 : 14
- (D) Infinity

Q147. PHY

When a positron and an electron collide at low energy, they annihilate to produce:

- (A) Alpha particles
- (B) One single γ -ray photon
- (C) Two γ -ray photons emitted in opposite directions
- (D) Characteristic X-rays

Q148. PHY

An electric motor does 140,000 J of work in lifting an elevator over a duration of 70 seconds. What is the average power output of the motor?

- (A) 0.50 mW
- (B) 2.0 W
- (C) 2.0 kW
- (D) 9.8 MW

Q149. PHY

The internal resistance of a chemical galvanic cell or battery arises primarily from the:

- (A) Electrolytic solution and internal components
- (B) Accelerating motion of conduction ions
- (C) Static charges on the exterior casing
- (D) External connecting terminals

Q150. PHY

A magnetic field is generated in space exclusively by:

- (A) Moving electric charges
- (B) Stationary electric charges
- (C) Both stationary and moving charges equally
- (D) Static neutral mass distributions

Q151. PHY

When additional air is pumped into a bicycle tire at constant temperature, the internal pressure increases primarily because:

- (A) More gas molecules strike the tire wall per second
- (B) The individual gas molecules expand in physical size
- (C) The gas molecules move farther apart from one another
- (D) The intermolecular attractive forces between gas molecules increase

Q152. PHY

The spatial distance traveled by a periodic wave during one complete temporal period is defined as its:

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

Q153. PHY

Radioactive isotopes can be artificially synthesized by bombarding stable target nuclei with:

- (A) Neutrons
- (B) Visible light photons
- (C) Low-energy conduction electrons
- (D) Thermal positrons

Q154. PHY

A stone is released from rest from the top of a building 80 m above the ground. Neglecting air resistance and taking $g = 10 \text{ m/s}^2$, how long will it take to reach the ground?

- (A) 2 s
- (B) 4 s
- (C) 8 s
- (D) 10 s

Q155. PHY

The magnetic flux through a planar conducting loop is zero when the angle between the magnetic field vector and the vector area of the loop is:

- (A) 0°
- (B) 90°
- (C) 60°
- (D) 30°

Q156. PHY

Dental restorative materials used for fillings in teeth should ideally be fabricated from a substance that:

- (A) Does not undergo thermal expansion when heated
- (B) Expands at the same thermal rate as natural tooth enamel and dentin
- (C) Expands significantly less than the tooth structure when heated
- (D) Expands significantly more than the tooth structure when heated

Q157. PHY

When an unstable radioactive parent nucleus emits a pure gamma-ray photon, the mass number (A) of the daughter nucleus:

- (A) Remains unchanged
- (B) Increases by 2 units
- (C) Decreases by 1 unit
- (D) Increases by 1 unit

Q158. PHY

In the International System of Units (SI), centripetal force is measured in:

- (A) Joules (J)
- (B) Newtons (N)
- (C) Teslas (T)
- (D) Watts (W)

Q159. PHY

A charged particle moves through a uniform electric field established between two oppositely charged parallel metal plates. To calculate the electrostatic force acting on the particle, which quantity is NOT required?

- (A) Magnitude of the particle's charge
- (B) Speed of the charged particle
- (C) Separation distance between the plates
- (D) Potential difference between the plates

Q160. PHY

Which of the following physical systems provides the best real-world approximation of uniform circular motion?

- (A) Orbital motion of the Earth around the Sun
- (B) Motion of a mass whirled on a string in a vertical circle
- (C) Motion of the tip of the minute hand of a functioning wall clock
- (D) Rotational precession of a spinning toy top

Q161. PHY

A body of mass 5 kg moves with an initial linear momentum of 10 kg m/s. A constant force of 0.2 N acts on it in the direction of motion for 10 seconds. What is the increase in its kinetic energy?

- (A) 2.8 J
- (B) 3.2 J
- (C) 3.8 J
- (D) 4.4 J

Q162. PHY

If two bodies of identical mass move with identical speeds, we can definitively conclude that:

- (A) Their linear momenta are identical vectors
- (B) Their linear momenta can be different from each other
- (C) Their kinetic energies must be different from each other
- (D) Their total mechanical energies must be zero

Q163. PHY

The electric field intensity at a distance of 4 meters from an isolated point charge is 200 N/C. If the distance is reduced to 2 meters, what will the new electric field intensity be?

- (A) 400 N/C
- (B) 800 N/C
- (C) 600 N/C
- (D) 1200 N/C

Q164. PHY

In the Compton scattering shift equation $\Delta\lambda = \frac{h}{m_0c}(1 - \cos\theta)$, the physical units of the quantity $\Delta\lambda$ are units of:

- (A) Length
- (B) Time
- (C) Mass
- (D) Frequency

Q165. PHY

An electrostatic capacitor stores energy within its plates in the form of:

- (A) Kinetic energy of moving charges
- (B) Electrical potential energy in the electric field
- (C) Thermal internal energy
- (D) Electromagnetic light energy

Q166. PHY

When the separation distance between two point charges is halved, the electrostatic Coulomb force between them becomes:

- (A) One-fourth of the initial force
- (B) Four times the initial force
- (C) Double the initial force
- (D) One-half of the initial force

Q167. PHY

When an object moves along a straight line in a constant direction without reversing, its displacement vector magnitude coincides with its:

- (A) Total path length (distance)
- (B) Net applied force
- (C) Instantaneous acceleration
- (D) Total inertia

Q168. PHY

The speed of sound is noticeably faster in moist air than in dry air under identical temperature and pressure conditions because:

- (A) Moist air has a larger molar mass than dry air
- (B) The adiabatic index (γ) is significantly higher for moist air
- (C) The mass density of moist air is less than that of dry air
- (D) Water vapor molecules absorb sound waves more weakly

Q169. PHY

The electromotive force produced by an AC generator attains its maximum (peak) value when the plane of the rotating coil is:

- (A) Perpendicular to the magnetic field
- (B) Parallel to the magnetic field
- (C) Inclined at 45° to the magnetic field
- (D) Inclined at 60° to the magnetic field

Q170. PHY

During electronic transitions between bound atomic energy levels in an atom, which form of electromagnetic radiation CANNOT be emitted?

- (A) Gamma rays
- (B) Infrared radiation
- (C) Ultraviolet radiation
- (D) Visible light

Q171. PHY

Which of the following physical quantities is measured in kilowatt-hours (kWh)?

- Ⓐ Electric charge
- Ⓑ Electric current
- Ⓒ Electrical energy
- Ⓓ Electric power

Q172. PHY

The opposing conducting plates of a parallel-plate capacitor are physically separated by a layer of:

- Ⓐ Electrical insulating dielectric material
- Ⓑ Metallic conductors
- Ⓒ Semiconductor crystals
- Ⓓ Ohmic resistors

Q173. PHY

Stationary (standing) waves cannot transport which of the following through a medium?

- Ⓐ Energy only
- Ⓑ Mass only
- Ⓒ Both energy and mass
- Ⓓ Phase only

Q174. PHY

A child swings on a playground swing such that the minimum and maximum heights of the swing seat above the ground are 0.75 m and 2.0 m respectively. Assuming negligible friction and taking $g = 10 \text{ m/s}^2$, the maximum speed attained by the child is:

- Ⓐ 5 m/s
- Ⓑ 10 m/s
- Ⓒ 15 m/s
- Ⓓ 20 m/s

Q175. PHY

In an electrical transformer, the primary and secondary coils are coupled to each other:

- Ⓐ Electrically by common wiring
- Ⓑ Magnetically via a shared laminated ferromagnetic core
- Ⓒ Thermally through conductive paste
- Ⓓ Mechanically through rotating shafts

Q176. PHY

To calculate the electric field intensity surrounding an infinitely long uniform line of charge using Gauss's law, the most appropriate Gaussian surface is a:

- Ⓐ Concentric sphere
- Ⓑ Coaxial closed cylinder
- Ⓒ Symmetrical cube
- Ⓓ Rectangular cuboid

ENG SECTION: ENGLISH

Questions 177 to 194 (18 MCQs)

Q177. ENG

Choose the word with the correct spelling:

- (A) Patriarchal
- (B) Patreachal
- (C) Partriarchel
- (D) Patriarrchal

Q178. ENG

The antonym of the word 'asylum' is:

- (A) Security
- (B) Refuge
- (C) Danger
- (D) Protection

Q179. ENG

Choose the grammatically correct sentence:

- (A) She is good in speaking English.
- (B) She is good with speaking English.
- (C) She is good at speaking English.
- (D) She is well at speaking English.

Q180. ENG

Choose the sentence that exhibits correct punctuation:

- (A) It is mentioned in the notification all of us should read it.
- (B) It is mentioned in the notifications all of us should read it.
- (C) It is mentioned in the notification? all of us should read it.
- (D) It is mentioned in the notification, all of us should read it.

Q181. ENG

Choose the correct verb form to fill in the blank:

I _____ with my parents.

- (A) Lives
- (B) Am living
- (C) Is living
- (D) Shall living

Q182. ENG

Fill in the blank with the most appropriate word:

The melody is _____, not energetic like the hymns in church.

- (A) Plaintive
- (B) Baffling
- (C) Blissful
- (D) Perplexing

Q183. ENG

Choose the correct tense form to fill in the blank:

When I opened my eyes, I _____ a strange sight.

- (A) Am seeing
- (B) Have seen
- (C) Was seen
- (D) Saw

Q184. ENG

Fill in the blanks with the correct verb combination:

The neighbours _____ so loudly last night that they _____ all awake until after midnight.

- (A) Are shouting / are keeping
- (B) Were shouting / kept
- (C) Shouted / have been keeping
- (D) Have shouted / had kept

Q185. ENG

Which of the following verb forms correctly fills in the blank?

Bread and butter is what the poor _____ today.

- (A) Need
- (B) Needs
- (C) Needed
- (D) Needing

Q186. ENG

Correct the run-on comma splice in the given sentence:

I like cats, I hate dogs.

- (A) I like cats: I hate dogs.
- (B) I like cats I hate dogs.
- (C) I like cats' I hate dogs.
- (D) I like cats but I hate dogs.

Q187. ENG

Choose the sentence that conveys the same meaning as the following sentence:

I will not tolerate his rudeness.

- (A) I will not put up for his rudeness.
- (B) I will not put up with his rudeness.
- (C) I will not put up to his rudeness.
- (D) I will not put up by his rudeness.

Q188. ENG

Which of the following sentences is grammatically correct?

- (A) The Bible says a person comes from the earth and has to go back to the earth.
- (B) The Bible says the person comes from the earth and has to go back to the earth.
- (C) The Bible says person comes from the earth and has to go back to the earth.
- (D) The Bible say the person comes from the earth and has to go back to the earth.

Q189. ENG

Identify the part of the following sentence that contains a grammatical error:

I think it is they who is wrong.

- (A) it
- (B) who
- (C) is
- (D) wrong

Q190. ENG

Identify the correct spelling of the astronomical galaxy name:

- (A) Andoromeda
- (B) Andromida
- (C) Andremode
- (D) Andromeda

Q191. ENG

Fill in the blank with the appropriate preposition:

Do not hanker _____ worldly pleasures.

- (A) For
- (B) After
- (C) Towards
- (D) About

Q192. ENG

Fill in the blank with the correct choice:

Whatever she wants to do _____ fine with me.

- (A) the
- (B) is
- (C) are
- (D) were

Q193. ENG

The vocabulary word INCLUSIVE is closest in meaning to:

- (A) Exclusive
- (B) Comprehensive
- (C) Diverse
- (D) Embracing

Q194. ENG

What does the word 'outmoded' mean in the following sentence?

The designer window treatments in her house, installed 17 years ago, were outmoded.

- (A) Unnecessary
- (B) Pointless
- (C) Out-of-date
- (D) Worthless

LOGIC SECTION: LOGICAL REASONING

Questions 195 to 200 (6 MCQs)

Q195. LOGIC

Read the statements and determine which conclusions necessarily follow:

Statements:

1. All children are silly people.
2. Some silly people are rich people.
3. All rich people are big shots.

Conclusions:

- I. Some silly people are children.
- II. Some rich people are children.
- III. Some silly people are big shots.

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

Q196. LOGIC

X, Y, and Z are three whole numbers strictly greater than 23 and strictly less than 31 (i.e., from 24 to 30 inclusive).

1. X is a prime number.
2. Y is the largest odd number in the range.
3. Z is the smallest even number in the range.

What are the values of X, Y, and Z?

- (A) X = 31, Y = 29, Z = 24
(B) X = 29, Y = 29, Z = 24
(C) X = 23, Y = 29, Z = 24
(D) X = 27, Y = 31, Z = 26

Q197. LOGIC

Read the statement and decide which suggested course(s) of action logically follow:

Statement: An invigilator catches a student attempting to cheat for the third time in a professional board examination.

Courses of Action:

- I. Remove the student from the examination room and cancel his exam attempt.
- II. Give the student another stern warning.

- (A) I only
(B) II only
(C) Both I and II
(D) Neither I nor II

Q198. LOGIC

Analyze the following premises and determine which conclusion logically follows:

Statements:

1. All doctors are professionals.
2. Some professionals are wealthy.

- (A) All doctors are wealthy
(B) Some doctors are wealthy
(C) No doctors are wealthy
(D) None of these follows

Q199. LOGIC

In a certain code language, 'TRAIN' is written as 'UQBHO'. Using the same encoding rule, how is 'PLANE' written?

- (A) QKBMF
(B) QKBOD
(C) OKZMF
(D) QMBOF

Q200. LOGIC

Find the next number in the numerical series:

3, 8, 15, 24, 35, ?

- (A) 45
(B) 46
(C) 47
(D) 48

OFFICIAL VERIFIED ANSWER KEY

BUMHS Quetta MDCAT 2022 Official Paper - Rapid Self-Grading Grid

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

BIOLOGY
02. Biomolecules

Diastase (amylase) acts on which of the following substrates?

CORE CONCEPT & DERIVATION

Diastase is a historic term for α -amylase, an enzyme that catalyzes the breakdown of complex carbohydrates into simpler sugars.

Formula / Rule / Reaction:



Solution:

- Amylase (diastase) specifically cleaves the internal $\alpha(1 \rightarrow 4)$ -glycosidic bonds of amylose and amylopectin present in starch.
- This enzymatic hydrolysis yields maltose, maltotriose, and limit dextrins.

Why other options are incorrect:

- **Option A:** Maltose is the disaccharide product of starch breakdown, hydrolyzed by maltase.
- **Option B:** Sucrose is a disaccharide cleaved specifically by sucrase (invertase).
- **Option C:** Lactose is milk sugar hydrolyzed specifically by lactase into glucose and galactose.

Question #2 Key: (D)

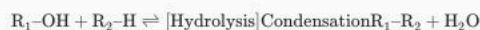
BIOLOGY
02. Biomolecules

Which of the following processes is antagonistic to condensation?

CORE CONCEPT & DERIVATION

Condensation joins monomers together by releasing a water molecule, whereas hydrolysis breaks bonds between monomers by inserting a water molecule.

Formula / Rule / Reaction:



Solution:

- Condensation (dehydration synthesis) forms macromolecules by eliminating water.
- Hydrolysis is the direct chemical reverse: water is split into -H and -OH groups to cleave polymers into individual monomers.

Why other options are incorrect:

- **Option A:** Decarboxylation involves the removal of a carboxyl group as carbon dioxide.
- **Option B:** Hydration is the addition of water across an unsaturated bond without macromolecular cleavage.
- **Option C:** Dehydration is synonymous with condensation in biological polymerization reactions.

Question #3 Key: (A)

BIOLOGY
02. Biomolecules

Which statement is wrong about saturated fats?

CORE CONCEPT & DERIVATION

Saturated fatty acids contain only single carbon-carbon bonds, holding the maximum possible number of hydrogen atoms.

Formula / Rule / Reaction:



Solution:

- Saturated fatty acids have fully saturated carbon backbones with no double bonds ($\text{C} = \text{C}$).
- Molecules with multiple double bonds are polyunsaturated fats, making Option A false and the correct choice.

Why other options are incorrect:

- **Option B:** Animal fats (such as butter and lard) are predominantly composed of saturated fatty acids.
- **Option C:** Saturated fatty acids hold the maximum hydrogen content compared to unsaturated counterparts with identical carbon lengths.
- **Option D:** Linear, saturated hydrocarbon chains pack tightly, giving them higher melting points and causing them to solidify at room temperature.

Question #4 Key: (A)

BIOLOGY
11. Support & Movement

Which of the following is classified as a connective tissue?

CORE CONCEPT & DERIVATION

Animal bodies consist of four primary tissue types: epithelial, connective, muscular, and nervous tissue.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Connective tissue is characterized by cells suspended in an extracellular matrix containing collagen or elastic fibers.
- Cartilage is a specialized supporting connective tissue consisting of chondrocytes embedded in a firm, gel-like chondrin matrix.

Why other options are incorrect:

- **Option B:** Epithelium forms protective cellular sheets covering body surfaces and lining internal cavities.
- **Option C:** Muscle tissue consists of excitable, contractile fibers specialized for mechanical motion.
- **Option D:** Nervous tissue consists of neurons and glial cells specialized for electrical signal transmission.

Question #5 Key: (C)BIOLOGY
05. Acellular Life

A virion is designated as which of the following?

CORE CONCEPT & DERIVATION

A virion is the complete, mature, and structurally intact infectious viral particle existing in an extracellular state.

Formula / Rule / Reaction:

$$\text{Virion} = \text{Capsid} + \text{Nucleic Acid Genome} (\pm \text{Envelope})$$

Solution:

- When outside a permissive host cell, a virus exists as a metabolically inert unit termed a virion.
- The virion contains the viral genome surrounded by a protein coat (capsid) and, in some species, a lipid envelope.

Why other options are incorrect:

- **Option A:** Viral enzymes (such as reverse transcriptase or integrase) are specific protein components inside the particle.
- **Option B:** The viral genome is strictly the nucleic acid core (DNA or RNA) alone.
- **Option D:** Viruses do not contain lysosomes or cellular organelles.

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

A cell without a cell wall will burst when placed in which of the following?

CORE CONCEPT & DERIVATION

In the absence of a rigid cell wall, osmotic influx of water causes animal cells to swell and undergo osmotic lysis.

Formula / Rule / Reaction:

$$\Psi_{\text{ext}} > \Psi_{\text{int}} \implies \text{Endosmosis into the cell}$$

Solution:

- A hypotonic solution has a higher water potential (lower solute concentration) than the cytoplasm.
- Water moves into the cell via endosmosis. Without a rigid cell wall to generate opposing wall pressure (turgor pressure), the plasma membrane ruptures.

Why other options are incorrect:

- **Option B:** In a hypertonic solution, water leaves the cell via exosmosis, causing cell shrinkage (crenation).
- **Option C:** In an isotonic solution, dynamic equilibrium exists with no net water flux.
- **Option D:** A solution with higher electrolyte concentration than the cell is hypertonic, leading to shrinkage rather than bursting.

Question #7 Key: (B)BIOLOGY
13. Chemical Coordination

Long term physiological controls such as rate of growth and sexual maturity are regulated by:

CORE CONCEPT & DERIVATION

Endocrine coordination utilizes chemical messengers (hormones) transported via the circulatory system to manage long-term developmental processes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Nervous coordination provides immediate, short-lived responses via electric impulses.
- Hormones exert sustained, long-term regulatory control over cell division, tissue differentiation, growth rate, and secondary sexual characteristics.

Why other options are incorrect:

- **Option A:** Neurons mediate fast-acting, short-duration reflexes and behavioral adjustments.
- **Option C:** Glands are the anatomical structures that secrete hormones, not the direct chemical signals.
- **Option D:** The hypothalamus is an endocrine/neuroendocrine center, but the actual direct physiological control is exerted by circulating hormones.

Question #8 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

In which human blood group are both A and B antigens present on erythrocytes?

CORE CONCEPT & DERIVATION

The ABO blood group system is governed by codominant alleles producing specific oligosaccharide antigens on the erythrocyte membrane.

Formula / Rule / Reaction:

$$\text{Genotype } I^A I^B \implies \text{Expression of both Antigen A and Antigen B}$$

Solution:

- Allele I^A produces N-acetylgalactosaminyltransferase (Antigen A).
- Allele I^B produces galactosyltransferase (Antigen B).
- Heterozygous individuals with genotype $I^A I^B$ express both antigens codominantly on red blood cell surfaces.

Why other options are incorrect:

- **Option A:** Blood group A erythrocytes carry only antigen A.
- **Option B:** Blood group B erythrocytes carry only antigen B.
- **Option D:** Blood group O erythrocytes carry neither antigen A nor antigen B.

Question #9 Key: (C)BIOLOGY
01. Cell

Facilitated diffusion involves carrier molecules. Chemically, these carriers are:

CORE CONCEPT & DERIVATION

Facilitated diffusion is passive, protein-mediated transport across biological membranes down an electrochemical or concentration gradient.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Lipid bilayers are impermeable to large polar molecules and ions.
- Membrane transport proteins (permeases, carriers, and channel proteins) bind specific solutes, undergo conformational changes, and facilitate passage without metabolic energy consumption.

Why other options are incorrect:

- **Option A:** Glycolipids function in cell-to-cell recognition and surface stability, not carrier transport.
- **Option B:** Pure lipids form the hydrophobic barrier that restricts passive solute movement.
- **Option D:** Carbohydrates attach as oligosaccharides to proteins and lipids on the external face for recognition.

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

Who proposed the fluid mosaic model of the plasma membrane?

CORE CONCEPT & DERIVATION

The fluid mosaic model describes the plasma membrane as a dynamic phospholipid bilayer containing intercalated proteins.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- S. J. Singer and Garth L. Nicolson proposed the fluid mosaic model in 1972.
- It replaced earlier sandwich models by establishing that globular proteins float within or span a fluid phospholipid bilayer.

Why other options are incorrect:

- **Option A:** Lorenz Oken proposed early concepts of cell theory; Robert Brown described the cell nucleus.
- **Option B:** George Palade discovered ribosomes; Robert Brown discovered the cell nucleus.
- **Option D:** Christian de Duve discovered lysosomes and peroxisomes.

Question #11 Key: (C)BIOLOGY
02. Biomolecules

Which of the following represents the two simplest amino acids?

CORE CONCEPT & DERIVATION

Amino acids consist of a central α -carbon, an amino group, a carboxyl group, and a variable side chain (R group).

Formula / Rule / Reaction:

Glycine: $R = -H$; Alanine: $R = -CH_3$

Solution:

- Glycine is the simplest amino acid, possessing a single hydrogen atom as its R group.
- Alanine is the second simplest, having a single methyl group ($-CH_3$) as its R group.

Why other options are incorrect:

- **Option A:** Trypsin is a proteolytic digestive enzyme, not an amino acid.
- **Option B:** Trypsin is a pancreatic enzyme.
- **Option D:** Glutamate contains a complex acidic side chain ($-CH_2CH_2COO^-$).

Question #12 Key: (A)BIOLOGY
02. Biomolecules

Which of the following animals does not have a soft, unsegmented body typical of molluscs?

CORE CONCEPT & DERIVATION

Molluscs are characterized by soft, unsegmented bodies typically enclosed in a mantle, while annelids exhibit metameric segmentation.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Hirudo (the medicinal leech) is an annelid possessing a distinctly segmented, muscular body wall covered by a tough cuticle.
- Unio (freshwater mussel), Sepia (cuttlefish), and Loligo (squid) are true soft-bodied molluscs.

Why other options are incorrect:

- **Option B:** Unio belongs to Phylum Mollusca (Class Bivalvia) with a characteristic soft visceral mass.
- **Option C:** Sepia belongs to Phylum Mollusca (Class Cephalopoda).
- **Option D:** Loligo belongs to Phylum Mollusca (Class Cephalopoda).

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

The stage of the menstrual cycle that begins immediately after ovulation is:

CORE CONCEPT & DERIVATION

The human uterine cycle consists of three phases: menstrual, proliferative (follicular), and secretory (luteal) phases.

Formula / Rule / Reaction:

Ovulation (Day 14) $\Rightarrow$ Luteal Phase/Secretory Phase (Days 15–28)

Solution:

- After the release of the secondary oocyte during ovulation, the remnants of the ovarian follicle transform into the corpus luteum.
- Progesterone secreted by the corpus luteum stimulates the endometrium to secrete glycogen and become vascularized (secretory phase).

Why other options are incorrect:

- **Option A:** The menstrual stage occurs at the start of the cycle (days 1 to 5) when fertilization fails.
- **Option B:** The follicular stage occurs in the ovary prior to ovulation (days 1 to 13).
- **Option C:** The proliferative stage is the uterine counterpart to the follicular phase preceding ovulation.

Question #14 Key: (B)BIOLOGY
02. Biomolecules

Animals characterized by jointed appendages and a chitinous exoskeleton belong to phylum:

CORE CONCEPT & DERIVATION

Phylum Arthropoda is the largest animal phylum, defined by jointed appendages and an insoluble cuticle composed of chitin and protein.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The term 'Arthropoda' derives from 'arthron' (joint) and 'podos' (foot).
- Their key synapomorphies include segmented bodies with paired jointed appendages and a hardened chitinous exoskeleton that undergoes periodic ecdysis (molting).

Why other options are incorrect:

- **Option A:** Chordates possess a notochord, dorsal hollow nerve cord, and internal bone/cartilage skeletons.
- **Option C:** Annelids are soft-bodied segmented worms with a hydrostatic skeleton.
- **Option D:** Molluscs have soft, unsegmented bodies, often protected by a calcareous shell rather than jointed chitinous appendages.

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

Similarity in the molecular structure and genetic mechanism of DNA and RNA provides evidence th...

CORE CONCEPT & DERIVATION

Monophyly describes an evolutionary lineage of organisms sharing ancestry from a single common evolutionary precursor.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- All living cellular organisms utilize double-stranded DNA, universal triplet codons, mRNA transcription, and tRNA-mediated translation.
- This profound biochemical and genetic conservation demonstrates that all extant life originated from a single universal common ancestor (monophyletic origin).

Why other options are incorrect:

- **Option A:** 'Heterophyletic' is a non-standard taxonomic term denoting independent or multiple evolutionary ancestries.
- **Option C:** Paraphyletic groups include a common ancestor but exclude some of its descendants.
- **Option D:** Polyphyletic groups are composed of organisms derived from two or more distinct ancestral sources.

Question #16 Key: (A)BIOLOGY
05. Acellular Life

Which viruses are designated as naked viruses?

CORE CONCEPT & DERIVATION

Viruses lacking an outer host-derived lipid bilayer envelope are classified as non-enveloped or naked viruses.

Formula / Rule / Reaction:

Naked Virus = Nucleocapsid only (Capsid + Genome)

Solution:

- Naked viruses consist exclusively of a protein shell (capsid) surrounding the nucleic acid genome.
- They are typically more resistant to heat, drying, and detergents than lipid-enveloped viruses.

Why other options are incorrect:

- **Option B:** Enveloped viruses possess an outer phospholipid and glycoprotein envelope acquired from host cell membranes.
- **Option C:** Prions are infectious, misfolded proteins completely lacking nucleic acids.
- **Option D:** Viroids are circular, infectious single-stranded RNA molecules that lack any protein capsid.

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

Maltose is classified as a:

CORE CONCEPT & DERIVATION

Disaccharides are carbohydrates consisting of exactly two monosaccharide units joined by a covalent glycosidic bond.

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

- Maltose (malt sugar) is composed of two α -D-glucose molecules linked by an $\alpha(1 \rightarrow 4)$ -glycosidic linkage.
- Because it contains exactly two monomer subunits, it is specifically designated as a disaccharide.

Why other options are incorrect:

- **Option A:** Polysaccharides (like starch and glycogen) consist of hundreds to thousands of monosaccharide units.
- **Option C:** While disaccharides fall broadly under oligosaccharides (2 to 10 sugars), 'disaccharide' is the precise and correct biological category.
- **Option D:** Monosaccharides are single sugar units like glucose and fructose that cannot be hydrolyzed further.

Question #18 Key: (C)BIOLOGY
06. Digestion/Nutrition

Lingual lipase is secreted by which of the following glands?

CORE CONCEPT & DERIVATION

Lingual lipase is an acid-stable triacylglycerol lipase initiated in the oral cavity for lipid digestion.

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

- Lingual lipase is secreted by the serous von Ebner's glands situated beneath the circumvallate and foliate papillae of the tongue.
- It initiates lipid digestion by cleaving short- and medium-chain fatty acids from triglycerides.

Why other options are incorrect:

- **Option A:** Parotid salivary glands secrete salivary amylase (ptyalin).
- **Option B:** Submandibular glands secrete a seromucous mixture containing amylase and mucus.
- **Option D:** The pancreas secretes pancreatic lipase into the duodenum.

Question #19 Key: (D)BIOLOGY
02. Biomolecules

Which structural protein forms the primary organic matrix of bone and cartilage?

CORE CONCEPT & DERIVATION

Collagen is the most abundant fibrous structural protein in animals, providing tensile strength to connective tissues.

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

- The extracellular matrix of bone is composed of type I collagen fibers impregnated with hydroxyapatite crystals.
- Cartilage matrix is formed largely of type II collagen fibers embedded in a chondroitin sulfate ground substance.

Why other options are incorrect:

- **Option A:** Myoglobin is an intracellular hemoprotein responsible for oxygen storage in muscle tissue.
- **Option B:** Hemoglobin is a tetrameric transport protein carrying oxygen in erythrocytes.
- **Option C:** Fibrinogen is a soluble plasma glycoprotein converted to insoluble fibrin during blood clotting.

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

How many distinct phenotypes are possible in the human ABO blood group system?

CORE CONCEPT & DERIVATION

The ABO blood group is determined by three multiple alleles (I^A , I^B , and i) producing four clinical phenotypes.

Formula / Rule / Reaction:

$$\text{Number of genotypes} = \frac{n(n+1)}{2} = \frac{3(4)}{2} = 6; \quad \text{Phenotypes} = 4$$

Solution:

- The three alleles combine into 6 genotypes: $I^A I^A$, $I^A i$, $I^B I^B$, $I^B i$, $I^A I^B$, and ii .
- Due to dominance and codominance, these correspond to 4 distinct phenotypes: Blood Group A, Blood Group B, Blood Group AB, and Blood Group O.

Why other options are incorrect:

- **Option A:** Two phenotypes is an underestimate, ignoring the multiallelic and codominant nature.
- **Option C:** Six is the total number of underlying diploid genotypes, not phenotypes.
- **Option D:** Eight would represent ABO combined with Rh factor phenotypes, which is not asked here.

Question #21 Key: (A)BIOLOGY
07. Circulation / Transport

Histamine released during allergic or inflammatory reactions causes blood vessels to:

CORE CONCEPT & DERIVATION

Histamine is a biogenic vasoactive amine released by mast cells and basophils during acute inflammatory and allergic cascades.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Histamine binds to H_1 receptors on precapillary arterioles, activating endothelial nitric oxide synthase.
- This promotes vascular smooth muscle relaxation, causing localized vasodilation and increased vascular permeability.

Why other options are incorrect:

- **Option B:** Vasoconstriction is mediated by molecules like endothelin and thromboxane A_2 .
- **Option C:** Vascular blockage (thrombosis) is mediated by platelet plugs and coagulation cascades.
- **Option D:** Histamine causes endothelial gap formation, not structural rupture of vessel walls.

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

Which of the following functions is characteristic of the smooth endoplasmic reticulum?

CORE CONCEPT & DERIVATION

Smooth endoplasmic reticulum (SER) participates in lipid synthesis, drug detoxification, carbohydrate metabolism, and intracellular ion regulation.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In specialized excitable cells (such as sarcoplasmic reticulum in muscle fibers and specialized tubular networks in neurons), the SER actively releases and sequesters Ca^{2+} ions.
- This regulated calcium release is directly responsible for excitation-contraction coupling and impulse transmission, as detailed in provincial MDCAT textbooks.

Why other options are incorrect:

- **Option A:** Waste removal and intracellular disposal are handled primarily by lysosomes and excretory vacuoles.
- **Option C:** Protein metabolism and translation are handled by ribosomes and the rough endoplasmic reticulum (RER).
- **Option D:** Intracellular digestion is carried out by lysosomes containing acid hydrolases.

Question #23 Key: (A)BIOLOGY
04. Bioenergetics

Maximum photosynthetic rate occurs when a plant is illuminated with:

CORE CONCEPT & DERIVATION

The action spectrum of photosynthesis reveals distinct peaks corresponding to the light absorption profiles of chlorophylls a and b .

Formula / Rule / Reaction:

$$\text{Rate of Photosynthesis} \propto \text{Photochemical Quantum Yield}$$

Solution:

- Chlorophyll absorbs photons primarily in blue ($\approx 430 \text{ nm}$) and red ($\approx 670 \text{ nm}$) regions.
- Because blue photons possess excess energy that is partially dissipated as heat during internal conversion, red light delivers the highest photochemical quantum yield and photosynthetic efficiency.

Why other options are incorrect:

- **Option B:** Green light is largely reflected and transmitted by chlorophyll, producing the lowest photosynthetic activity.
- **Option C:** Yellow light is poorly absorbed by photosynthetic pigments.
- **Option D:** Blue light is strongly absorbed, but excess photon energy is lost as heat, making it less efficient than red light per absorbed photon.

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

Which of the following prokaryotic microorganisms naturally lacks a peptidoglycan cell wall?

CORE CONCEPT & DERIVATION

Most prokaryotes possess rigid cell walls, but members of the genus *Mycoplasma* are naturally wall-less.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- *Mycoplasma* species naturally lack a peptidoglycan cell wall, making them pleomorphic and completely resistant to β -lactam antibiotics like penicillin.
- Their fragile plasma membranes are stabilized by sterols acquired from the host environment.

Why other options are incorrect:

- **Option A:** Archaeobacteria possess cell walls containing pseudopeptidoglycan, polysaccharides, or S-layer proteins.
- **Option B:** Cyanobacteria possess typical Gram-negative peptidoglycan cell walls.
- **Option C:** Eubacteria generally possess cell walls composed of peptidoglycan (murein).

Question #25 Key: (A)BIOLOGY
05. Acellular Life*Poliovirus is an example of which morphological class of viruses?***CORE CONCEPT & DERIVATION**

Viruses exhibit geometric capsid symmetries including icosahedral (spherical), helical (rod-shaped), and complex structures.

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

- Poliovirus belongs to the Picornaviridae family.
- It is a non-enveloped, positive-sense single-stranded RNA virus with a spherical icosahedral capsid measuring approximately 30 nm in diameter.

Why other options are incorrect:

- **Option B:** Tadpole-shaped morphology is characteristic of T-even bacteriophages (such as T2 and T4).
- **Option C:** Rod-shaped (rigid helical) morphology is characteristic of Tobacco Mosaic Virus (TMV).
- **Option D:** Helical morphology is characteristic of influenza, rabies, and measles viruses.

Question #26 Key: (A)BIOLOGY
14. Reproduction*The average normal human sperm count per milliliter of semen is:***CORE CONCEPT & DERIVATION**

Normal male fertility requires semen containing adequate concentrations of viable, motile spermatozoa.

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

- According to standard medical physiology and provincial textbooks, normal human ejaculatory fluid contains 20 to 150 million spermatozoa per milliliter.
- Counts falling below 20 million per milliliter are clinically defined as oligospermia.

Why other options are incorrect:

- **Option B:** 2 to 10 million represents severe oligospermia associated with subfertility.
- **Option C:** 20 to 150 thousand is critically below fertile thresholds.
- **Option D:** 2 to 10 thousand represents profound oligospermia approaching azoospermia.

Question #27 Key: (B)BIOLOGY
01. Cell*When and by whom was the Golgi apparatus discovered?***CORE CONCEPT & DERIVATION**

The Golgi apparatus was identified in the late nineteenth century using specialized silver nitrate staining techniques.

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

- Italian physician and histologist Camillo Golgi discovered this organelle in 1898 while studying cerebellar Purkinje neurons stained with his black reaction (silver impregnation).
- He originally referred to the structure as the 'internal reticular apparatus'.

Why other options are incorrect:

- **Option A:** 1888 is an incorrect year; Theodor Boveri introduced the term centrosome around that time.
- **Option C:** 1988 and the name George Golgi are historically incorrect.
- **Option D:** 1998 is an incorrect century.

Question #28 Key: (C)BIOLOGY
05. Acellular Life*Which of the following is classified as a DNA virus?***CORE CONCEPT & DERIVATION**

Viruses are classified based on whether their genome consists of deoxyribonucleic acid (DNA) or ribonucleic acid (RNA).

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

- Herpes simplex virus is an enveloped, double-stranded DNA (dsDNA) virus belonging to the Herpesviridae family.
- Poliovirus, influenza virus, and mumps virus are all RNA-containing viruses.

Why other options are incorrect:

- **Option A:** Poliovirus contains a positive-sense single-stranded RNA (+ssRNA) genome.
- **Option B:** Influenza virus contains a segmented, negative-sense single-stranded RNA (-ssRNA) genome.
- **Option D:** Mumps virus (a paramyxovirus) contains an unsegmented, negative-sense single-stranded RNA (-ssRNA) genome.

Question #29 Key: (C)BIOLOGY
03. Enzymes

The temperature at which a cold-inactivated enzyme regains its catalytic activity is known as:

CORE CONCEPT & DERIVATION

Enzymes display a specific range of operating temperatures bounded by minimum, optimum, and maximum limits.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- At very low temperatures, enzymes become reversibly inactivated because molecules lack the kinetic energy required for substrate collisions.
- The minimum temperature is defined as the lowest temperature threshold at which the enzyme begins to show detectable catalytic activity.

Why other options are incorrect:

- Option A:** Optimum temperature is the temperature at which the rate of enzymatic catalysis reaches its maximum peak.
- Option B:** Maximum temperature is the upper threshold beyond which thermal denaturation permanently inactivates the enzyme.
- Option D:** 'Favorable temperature' is a vague, non-technical term.

Question #30 Key: (A)BIOLOGY
03. Enzymes

The optimum pH for digestive enzymes of the stomach (such as pepsin) is:

CORE CONCEPT & DERIVATION

Every enzyme has an optimum pH at which its tertiary conformation exposes an active catalytic site with appropriate ionization states.

Formula / Rule / Reaction:

Optimum pH for Pepsin $\approx 1.5 - 2.0$

Solution:

- Gastric parietal cells secrete hydrochloric acid (HCl), establishing a luminal gastric juice pH of 1.5 to 2.0.
- Pepsin is adapted to function in this highly acidic environment, where its catalytic aspartate residues remain active.

Why other options are incorrect:

- Option B:** Highly alkaline environments completely denature gastric pepsin.
- Option C:** Slightly acidic (pH 6 to 7) is typical of salivary amylase in the mouth.
- Option D:** Slightly alkaline (pH 7.5 to 8.5) is the optimum for duodenal and pancreatic enzymes such as trypsin and chymotrypsin.

Question #31 Key: (B)BIOLOGY
06. Digestion/Nutrition

Pseudomonas is an ecologically important example of which nutritional type of bacteria?

CORE CONCEPT & DERIVATION

Saprophytic bacteria obtain nutrients and metabolic energy by secreting enzymes to decompose dead organic matter.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Pseudomonas* species are widespread soil and aquatic heterotrophs.
- They act primarily as saprophytes (decomposers), breaking down hydrocarbons, plant debris, and complex organic substrates, recycling nutrients back into the ecosystem.

Why other options are incorrect:

- Option A:** Photoautotrophs (like cyanobacteria and green sulfur bacteria) synthesize carbohydrates using solar energy.
- Option C:** Symbiotic bacteria (like *Rhizobium*) maintain mutually beneficial associations with host organisms.
- Option D:** Parasitic bacteria depend strictly on living host tissues for sustenance.

Question #32 Key: (D)BIOLOGY
04. Bioenergetics

Which of the following respiratory processes is utilized by yeast in baking?

CORE CONCEPT & DERIVATION

Anaerobic respiration (fermentation) in yeast breaks down carbohydrates into alcohol and carbon dioxide gas in the absence of oxygen.

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

- In bread making, baker's yeast (*Saccharomyces cerevisiae*) ferments fermentable sugars anaerobically.
- The produced carbon dioxide gas becomes trapped within the gluten network, creating bubbles that cause the dough to rise and leaven.

Why other options are incorrect:

- Option A:** Aerobic respiration consumes oxygen and generates water and carbon dioxide, but rapid dough leavening relies on anaerobic fermentation.
- Option B:** External respiration refers to gas exchange across respiratory membranes in animals.
- Option C:** Internal respiration refers to systemic gas exchange between blood capillaries and body tissues.

Question #33 Key: (B)BIOLOGY
14. Reproduction*Treponema pallidum* is the causative organism of which disease?**CORE CONCEPT & DERIVATION***Treponema pallidum* is a pathogenic spirochete bacterium responsible for human venereal infection.**Formula / Rule / Reaction:***Factual recall / Qualitative concept.***Solution:**

- *Treponema pallidum* is an obligate, motile, helical spirochete that causes syphilis.
- The infection progresses through primary (painless chancre), secondary, latent, and tertiary stages.

Why other options are incorrect:

- **Option A:** Gonorrhea is caused by the Gram-negative diplococcus *Neisseria gonorrhoeae*.
- **Option C:** AIDS is caused by the retrovirus Human Immunodeficiency Virus (HIV).
- **Option D:** Diabetes mellitus is an endocrine/metabolic disorder related to insulin insufficiency or resistance.

Question #34 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics*When two or more independent genes interact so that each dominant allele contributes additively...***CORE CONCEPT & DERIVATION**

Polygenic inheritance occurs when multiple non-allelic genes exert cumulative or additive effects on a continuous quantitative phenotype.

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

- In polygenic (continuous) inheritance, several independent gene pairs govern a single phenotypic trait (such as human height, skin color, and wheat grain color).
- Each dominant allele contributes a small, equal increment to the overall expression of the trait in an additive manner.

Why other options are incorrect:

- **Option A:** Codominance occurs when both alleles of a single locus are simultaneously and fully expressed in heterozygotes.
- **Option C:** Epistasis occurs when one gene masks or modifies the phenotypic expression of an allele at a completely different locus.
- **Option D:** Incomplete dominance occurs when heterozygotes exhibit an intermediate blending of two parental alleles at a single locus.

Question #35 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics*A diploid chromosome number of 14 ([Formula]) is found in:***CORE CONCEPT & DERIVATION**

Different eukaryotic organisms possess characteristic, fixed diploid chromosome numbers in their somatic nuclei.

Formula / Rule / Reaction:

$$\text{Pisum sativum: } 2n = 14 \implies n = 7$$

Solution:

- The garden pea (*Pisum sativum*) studied by Gregor Mendel has a diploid complement of 14 chromosomes (7 homologous pairs).

Why other options are incorrect:

- **Option A:** Potato (*Solanum tuberosum*) has a diploid number of $2n = 48$.
- **Option B:** Fruit fly (*Drosophila melanogaster*) has a diploid number of $2n = 8$.
- **Option D:** Rat (*Rattus norvegicus*) has a diploid number of $2n = 42$.

Question #36 Key: (B)BIOLOGY
09. Respiration / Gaseous Exchange*In human anatomy, the trachea lies in which anatomical position relative to the esophagus?***CORE CONCEPT & DERIVATION**

Anatomical terminology designates anterior structures in humans as ventral and posterior structures as dorsal.

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

- The trachea (windpipe) descends down the neck into the mediastinum directly anterior (ventral) to the esophagus.
- The esophagus lies directly posterior (dorsal) to the cartilaginous rings of the trachea.

Why other options are incorrect:

- **Option A:** Dorsal means posterior; the esophagus lies dorsal to the trachea, not vice versa.
- **Option C:** Both organs lie along the midline (median sagittal plane), so they are not medial to each other.
- **Option D:** Lateral means to the side; neither the trachea nor the esophagus is situated laterally to the other.

Question #37 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

A hemophiliac male marries a hemophilia carrier female and they have 4 children (1 affected, 3 ...)

CORE CONCEPT & DERIVATION

Hemophilia is an X-linked recessive trait where each birth event represents an independent Mendelian probability.

Formula / Rule / Reaction:

$$\text{Cross: } X^hY \times X^H X^h \Rightarrow X^H X^h, X^h X^h, X^H Y, X^h Y$$

Solution:

- The carrier mother contributes either X^H (normal) or X^h (mutant) with equal probability (50%).
- The hemophiliac father contributes either X^h (to daughters) or Y (to sons).
- Potential offspring outcomes:
- $X^H X^h$: Carrier daughter (phenotypically normal, 25%)
- $X^h X^h$: Hemophiliac daughter (25%)
- $X^H Y$: Normal son (25%)
- $X^h Y$: Hemophiliac son (25%)
- Total probability of an affected child is $25\% + 25\% = 50\%$ (0.50). Previous birth history has no effect on independent probabilities.

Why other options are incorrect:

- Option A:** 0.25 is the probability for a normal carrier female or an affected male alone, not total affected offspring.
- Option C:** 0.75 is incorrect because two of the four genotypes produce affected phenotypes.
- Option D:** 1.00 would occur only if both parents were homozygous/hemizygous affected ($X^h X^h \times X^h Y$).

Question #38 Key: (A)BIOLOGY
01. Cell

Which of the following cell types does not possess a Golgi apparatus?

CORE CONCEPT & DERIVATION

Prokaryotic cells lack internal membrane-bound organelles, which are exclusively present in eukaryotes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Bacteria are prokaryotes that do not contain membrane-enclosed organelles such as mitochondria, endoplasmic reticulum, or the Golgi apparatus.
- Animal, plant, and fungal cells are all eukaryotes and contain functional Golgi complexes.

Why other options are incorrect:

- Option B:** Animal cells possess a prominent perinuclear Golgi apparatus for protein modification and packaging.
- Option C:** Plant cells possess Golgi bodies (often called dictyosomes) for synthesizing cell wall polysaccharides.
- Option D:** Fungal cells are eukaryotes and contain Golgi stacks for vesicular trafficking.

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

The corpus luteum primarily secretes which hormone?

CORE CONCEPT & DERIVATION

The corpus luteum is a temporary endocrine structure formed from the ruptured ovarian follicle after ovulation.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Following ovulation, luteinizing hormone (LH) stimulates the differentiation of follicular theca and granulosa cells into luteal cells.
- These luteal cells secrete large quantities of progesterone to prepare and maintain the endometrium for blastocyst implantation.

Why other options are incorrect:

- Option A:** Parathormone (PTH) is secreted by the parathyroid glands to regulate calcium homeostasis.
- Option B:** Oxytocin is synthesized in the hypothalamus and released from the posterior pituitary.
- Option D:** Testosterone is secreted primarily by testicular Leydig cells in males.

Question #40 Key: (B)BIOLOGY
07. Circulation / Transport

The maximum water potential ([Formula]) of pure water at standard temperature and atmospheric...

CORE CONCEPT & DERIVATION

Water potential is the chemical potential of water per unit volume relative to pure water under standard conditions.

Formula / Rule / Reaction:

$$\Psi_w = \Psi_s + \Psi_p; \text{ For pure water at 1 atm: } \Psi_s = 0, \Psi_p = 0 \implies \Psi_w = 0$$

Solution:

- Pure water possesses the highest possible free energy, which is set by international convention to exactly zero mega-pascals (0 MPa).
- Adding solutes lowers the water potential to negative values; therefore, 0 is the maximum possible value.

Why other options are incorrect:

- **Option A:** Negative values indicate aqueous solutions containing dissolved solutes.
- **Option C:** Water potential of unconfined pure water cannot exceed 0 under standard conditions.
- **Option D:** Positive values are only attained under strong external hydrostatic pressure ($\Psi_p > 0$), not in free pure water.

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

What is the scientific study of joints called?

CORE CONCEPT & DERIVATION

Anatomical terminology utilizes specialized Greek and Latin roots to classify biological disciplines.

Formula / Rule / Reaction:

$$\text{Arthro- (joint) + -logy (study of) = Arthrology}$$

Solution:

- Arthrology is the branch of anatomical science dedicated to the structural, functional, and pathological study of joints and articulations.

Why other options are incorrect:

- **Option A:** Arthralgia refers clinically to localized joint pain, not the scientific study of joints.
- **Option C:** Myology is the scientific study of muscles and muscular system physiology.
- **Option D:** Cytology is the microscopic study of cellular structure and function.

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

Which of the following organs functions as a major secondary lymphatic organ?

CORE CONCEPT & DERIVATION

Secondary lymphoid organs provide specialized microenvironments for antigen surveillance, presentation, and lymphocyte activation.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The spleen is the largest secondary lymphoid organ in the human body.
- Its white pulp contains B- and T-lymphocytes that mount immune responses to blood-borne pathogens, while its red pulp filters aged red blood cells.

Why other options are incorrect:

- **Option A:** The stomach is a primary digestive organ of the gastrointestinal tract.
- **Option B:** The kidney is an excretory and osmoregulatory organ filtering metabolic waste.
- **Option D:** The liver is a metabolic, digestive, and detoxifying organ.

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

Which statement is true regarding the nuclear envelope and its pores?

CORE CONCEPT & DERIVATION

The nuclear envelope is a double-membrane structure perforated by macromolecular nuclear pore complexes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Nuclear pore density varies dynamically according to transcriptional and metabolic activity.
- Undifferentiated or metabolically active cells (such as oocytes) possess up to 30,000 pores per nucleus, whereas differentiated, low-activity cells (such as erythrocytes during maturation) have as few as 3 to 4 pores.

Why other options are incorrect:

- **Option B:** Pore count is not constant; it changes dramatically based on cellular synthetic demands.
- **Option C:** The nuclear envelope is composed of two concentric lipid bilayers (inner and outer membranes).
- **Option D:** The outer nuclear membrane is continuous with the rough endoplasmic reticulum, not the Golgi complex.

Question #44 Key: (A)BIOLOGY
05. Acellular Life

The BCG (*Bacillus Calmette-Guerin*) vaccine is administered to provide immunity against:

CORE CONCEPT & DERIVATION

BCG is an attenuated live vaccine derived from *Mycobacterium bovis* that stimulates cell-mediated immunity against tuberculosis.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- BCG (*Bacillus Calmette-Guerin*) protects against pulmonary tuberculosis and severe disseminated disease (miliary TB and tuberculous meningitis) caused by *Mycobacterium tuberculosis*.

Why other options are incorrect:

- **Option B:** Typhoid fever is caused by *Salmonella typhi* and prevented by the Typhoid conjugate vaccine (TCV) or TAB vaccine.
- **Option C:** Cholera is caused by *Vibrio cholerae* and prevented by oral cholera vaccines (OCV).
- **Option D:** Bacterial pneumonia is commonly caused by *Streptococcus pneumoniae* and prevented by pneumococcal conjugate vaccines (PCV).

Question #45 Key: (C)BIOLOGY
14. Reproduction

Mitochondria are concentrated in which anatomical part of a human sperm?

CORE CONCEPT & DERIVATION

A mature spermatozoon is compartmentalized into head, neck, mid-piece, and tail to optimize motility and fertilization.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The mid-piece contains a compact spiral sheath of mitochondria (the mitochondrial spiral or nebenkern).
- These mitochondria produce ATP via oxidative phosphorylation to fuel the dynein ATPase arms that power flagellar beating in the tail.

Why other options are incorrect:

- **Option A:** The acrosome is an anterior cap-like vesicle on the sperm head derived from the Golgi apparatus and filled with hydrolytic enzymes.
- **Option B:** The head contains the highly condensed haploid nucleus.
- **Option D:** The tail (flagellum) consists of the axoneme with a 9 + 2 microtubule arrangement for propulsion.

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

Which of the following is not an example of the anatomical reduction or disuse of organs?

CORE CONCEPT & DERIVATION

Reduction through evolutionary or physiological disuse refers to the progressive atrophy or loss of vestigial structures.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Shedding of milk (deciduous) teeth is a natural developmental process (diphyodont dentition) where primary teeth are replaced by permanent adult dentition.
- It occurs through programmed root resorption, not from anatomical disuse or evolutionary regression.

Why other options are incorrect:

- **Option A:** The evolutionary loss of limbs in snakes represents an evolutionary consequence of burrowing adaptations and limb-bud regression.
- **Option C:** Muscle atrophy is a direct physiological consequence of muscular disuse or denervation.
- **Option D:** Non-functional human auricular muscles (extrinsic ear muscles) are classic vestigial organs of disuse.

Question #47 Key: (B)BIOLOGY
03. Enzymes

Cyanide acts as which type of enzyme inhibitor?

CORE CONCEPT & DERIVATION

Non-competitive inhibitors bind to an allosteric or metal-cofactor site distinct from the active site, inactivating the enzyme regardless of substrate concentration.

Formula / Rule / Reaction:

$$V_{\max} \text{ decreases, } K_m \text{ remains unchanged}$$

Solution:

- Cyanide (CN^-) irreversibly coordinates to the ferric (Fe^{3+}) iron ion in the heme prosthetic group of mitochondrial cytochrome c oxidase (Complex IV).
- Because cyanide does not compete with molecular oxygen for the catalytic binding pocket, it acts as a non-competitive inhibitor of the respiratory chain.

Why other options are incorrect:

- **Option A:** Competitive inhibitors bind directly to the active catalytic site and can be displaced by excess substrate.
- **Option C:** A co-enzyme is a non-protein organic cofactor required for catalytic activity.
- **Option D:** An activator increases enzymatic reaction rate or affinity.

Question #48 Key: (C)BIOLOGY
16. Evolution

Which of the following forms of life first evolved approximately 1.5 billion years ago?

CORE CONCEPT & DERIVATION

The timeline of biological evolution places the origin of unicellular eukaryotic organisms during the Proterozoic eon.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Prokaryotes arose approximately 3.5 to 3.8 billion years ago.
- Endosymbiotic events and microfossil records indicate that the earliest unicellular eukaryotes with true nuclei and organelles evolved approximately 1.5 to 1.8 billion years ago.

Why other options are incorrect:

- **Option A:** Prokaryotes appeared around 3.5 billion years ago, long before eukaryotes.
- **Option B:** Multicellular animals (metazoans) evolved much later, during the Ediacaran and Cambrian periods (approximately 600 million years ago).
- **Option D:** Seed plants (gymnosperms) did not appear until the late Devonian period (approximately 360 million years ago).

Question #49 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

Dominance describes the physiological effect of an allele over its partner allele occupying the...

CORE CONCEPT & DERIVATION

Alleles are alternative forms of a gene occupying the same relative genetic locus on homologous chromosome pairs.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Homologous chromosomes carry corresponding genetic loci inherited from maternal and paternal parents.
- Dominance occurs when the phenotypic expression of an allele masks that of its recessive partner allele located at the identical locus on the homologous chromosome.

Why other options are incorrect:

- **Option A:** Two alleles of a gene cannot occupy the exact same locus on a single chromosome simultaneously.
- **Option B:** Different loci on the same chromosome represent linked non-allelic genes.
- **Option D:** Different loci on homologous chromosomes also represent non-allelic interactions (such as epistasis).

Question #50 Key: (D)BIOLOGY
12. Nervous Coordination

During an involuntary reflex, the nerve impulse travels along a fixed pathway known as the:

CORE CONCEPT & DERIVATION

A reflex arc is the dedicated anatomical and neural circuitry that executes an involuntary reflex action.

Formula / Rule / Reaction:

Receptor → Sensory Neuron → Interneuron (Spinal Cord) → Motor Neuron → Effector

Solution:

- A reflex action is the rapid, involuntary physiological response to a stimulus.
- The physical anatomical pathway along which the afferent and efferent action potentials propagate is specifically termed the reflex arc.

Why other options are incorrect:

- **Option A:** 'Reflex action' describes the motor response itself, not the structural pathway.
- **Option B:** Reflex action of glands refers to glandular secretion rather than the neural conduit.
- **Option C:** Combining the action and arc conflates the functional response with the underlying anatomical pathway.

Question #51 Key: (A)BIOLOGY
04. Bioenergetics

Which of the following can be considered as metabolic waste products of bacteria?

CORE CONCEPT & DERIVATION

Fermentation pathways in bacteria dump reduced organic end products into the external environment as metabolic byproducts.

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

- Under anaerobic conditions, fermentative bacteria regenerate NAD^+ by reducing pyruvate.
- This biochemical process yields organic wastes including ethanol (alcoholic fermentation), lactic acid (lactic fermentation), and acetic acid (mixed acid fermentation).

Why other options are incorrect:

- **Option B:** Potassium and sulfur are essential elemental inorganic nutrients, not excretory metabolic end products.
- **Option C:** Glycogen and inorganic phosphates are stored intracellular reserve macromolecules, not excretory wastes.
- **Option D:** Glycogen and lipid droplets represent cellular energy storage reserves.

Question #52 Key: (C)BIOLOGY
09. Respiration / Gaseous Exchange

Most of the carbon dioxide in human blood is transported in which of the following forms?

CORE CONCEPT & DERIVATION

Carbon dioxide produced by cellular respiration is transported to the lungs primarily as bicarbonate ions dissolved in blood plasma.

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

- Approximately 70% of blood carbon dioxide is converted inside erythrocytes by carbonic anhydrase into carbonic acid, which dissociates into bicarbonate (HCO_3^-).
- Bicarbonate leaves red cells via the chloride shift to be carried in plasma.

Why other options are incorrect:

- Option A:** Carboxyhemoglobin is the abnormal complex formed when toxic carbon monoxide (CO) binds to hemoglobin.
- Option B:** Carbaminohemoglobin accounts for only approximately 23% of total carbon dioxide transport.
- Option D:** Physically dissolved CO_2 in plasma accounts for only about 7% of total transport.

Question #53 Key: (C)BIOLOGY
16. Evolution

Who proposed the evolutionary concept of the unity of life through common descent?

CORE CONCEPT & DERIVATION

The principle of the unity of life attributes the anatomical and biochemical commonalities of all organisms to descent with modification from common ancestors.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Charles Darwin articulated the concept of the unity of life in 'On the Origin of Species' (1859).
- He envisioned life as a branching tree where all species converge backward in time to shared ancestral lineages.

Why other options are incorrect:

- Option A:** Aristotle believed species were fixed, immutable entities arranged on a static hierarchical scale (Scala Naturae).
- Option B:** Jean-Baptiste Lamarck proposed the inheritance of acquired characteristics and independent evolutionary lineages.
- Option D:** Alfred Russel Wallace co-discovered natural selection but Darwin is historically recognized for establishing the theoretical concept of the unity of life.

Question #54 Key: (D)BIOLOGY
04. Bioenergetics

What is the number of hydrogen atoms in the molecular formula of Chlorophyll-a?

CORE CONCEPT & DERIVATION

Chlorophyll-a is the primary photosynthetic pigment consisting of a porphyrin head with coordinated magnesium and a phytol tail.

Formula / Rule / Reaction:

Molecular formula of Chlorophyll-a : $\text{C}_{55}\text{H}_{72}\text{MgN}_4\text{O}_5$

Solution:

- Chlorophyll-a has the molecular formula $\text{C}_{55}\text{H}_{72}\text{MgN}_4\text{O}_5$.
- The subscript for hydrogen is 72, which corresponds to seventy-two hydrogen atoms per molecule.

Why other options are incorrect:

- Option A:** Six is unrelated to any stoichiometric value in chlorophyll.
- Option B:** Fifty-five represents the number of carbon atoms (C_{55}).
- Option C:** Seventy is the number of hydrogen atoms in Chlorophyll-b ($\text{C}_{55}\text{H}_{70}\text{MgN}_4\text{O}_6$).

Question #55 Key: (C)BIOLOGY
16. Evolution

Alternation of generations (metagenesis) between polyp and medusa body forms is characteristic ...

CORE CONCEPT & DERIVATION

Metagenesis is the regular alternation between a sessile asexual polyp generation and a motile sexual medusa generation.

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

- Coelenterates (such as Obelia) exhibit dimorphism.
- The asexual sedentary polyp reproduces by budding to form free-swimming medusae, which reproduce sexually via gametes to form planula larvae.

Why other options are incorrect:

- Option A:** Annelids are triploblastic segmented worms that do not exhibit polyp-medusa metagenesis.
- Option B:** Arthropods undergo metamorphosis (instars/pupae) rather than polyp-medusa alternation.
- Option D:** Echinoderms exhibit bilateral larvae that metamorphose into pentaradial adults.

Question #56 Key: (B)BIOLOGY
06. Digestion/Nutrition

Which bacteria are ecologically designated as the primary scavengers and decomposers of the Earth...

CORE CONCEPT & DERIVATION

Saprophytic microorganisms mineralize dead biomass, driving global biogeochemical element cycles.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Saprophytic bacteria secrete extracellular hydrolytic enzymes to break down proteins, cellulose, and lipids in dead organic matter.
- By returning locked inorganic minerals to soil and water, they serve as the scavengers of the biosphere.

Why other options are incorrect:

- **Option A:** Parasitic bacteria infect living hosts and obtain nutrition at the expense of host fitness.
- **Option C:** Symbiotic bacteria live in mutualistic relationships with other living organisms.
- **Option D:** Photosynthetic bacteria are primary producers that synthesize organic carbon from light energy.

Question #57 Key: (D)BIOLOGY
01. Cell

Lysosomes were named based on which of the following criteria?

CORE CONCEPT & DERIVATION

The name 'lysosome' is derived from Greek roots denoting its enzymatic constituents and lytic digestive function.

Formula / Rule / Reaction:

'Lysis' (dissolution/breakdown) + 'Soma' (body) = Lysosome

Solution:

- Christian de Duve coined the term 'lysosome' to reflect its biochemical composition (rich in acid hydrolases) and its physiological role (intracellular lytic digestion of macromolecules).

Why other options are incorrect:

- **Option A:** Lysosomes are pleomorphic and vary widely in size and shape, meaning morphology did not govern their naming.
- **Option B:** Shape is not a defining characteristic because lysosomes appear as variable spherical vesicles.
- **Option C:** Structure alone does not account for the specific enzymatic 'lytic' functional root.

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

White matter in the central nervous system is predominantly composed of:

CORE CONCEPT & DERIVATION

Myelin sheaths consist of multiple concentric layers of lipid-rich plasma membrane that impart a glistening white appearance to nerve tracts.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In the central nervous system, oligodendrocytes produce myelin sheaths around neuronal axons.
- The high lipid content of these insulating sheaths gives white matter its characteristic color and facilitates saltatory conduction.

Why other options are incorrect:

- **Option A:** Dendrites are non-myelinated receptive processes found predominantly in gray matter.
- **Option C:** Neuronal cell bodies (somata) and unmyelinated fibers constitute gray matter.
- **Option D:** Unmyelinated axons lack thick lipid coatings and do not contribute to the white appearance of nerve tracts.

Question #59 Key: (A)BIOLOGY
03. Enzymes

The catalytic active site of an enzyme is directly composed of how many amino acid residues?

CORE CONCEPT & DERIVATION

Although an enzyme may contain hundreds of amino acids, only a small cluster of residues forms the catalytic active site.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The catalytic site consists of roughly 3 to 12 amino acid residues brought into spatial proximity by tertiary protein folding.
- The remaining bulk of the protein provides the structural scaffolding required to stabilize this active conformation.

Why other options are incorrect:

- **Option B:** 30 to 50 residues represents a substantial portion of an entire protein domain.
- **Option C:** 50 to 100 residues represents the total size of small globular proteins, not the active site alone.
- **Option D:** 100 to 1000 residues is the typical total length of large polypeptide chains.

Question #60 Key: (C)BIOLOGY
14. Reproduction

The hormone that makes the endometrium receptive for the implantation of a blastocyst is:

CORE CONCEPT & DERIVATION

Progesterone converts the estrogen-primed proliferative endometrium into a glandular, secretory tissue suitable for blastocyst nidation.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Progesterone secreted by the corpus luteum stimulates endometrial stromal cell decidualization, coiled gland growth, and glycogen accumulation.
- This prepares the uterine lining for blastocyst implantation and inhibits myometrial contractions.

Why other options are incorrect:

- **Option A:** FSH is an anterior pituitary gonadotropin that stimulates ovarian follicular recruitment.
- **Option B:** Estrogen stimulates endometrial cellular proliferation and repair prior to ovulation.
- **Option D:** LH triggers ovulation and luteal tissue formation but does not directly prepare the uterine stroma.

Question #61 Key: (A)BIOLOGY
13. Chemical Coordination

Acromegaly is an endocrine disorder caused by hypersecretion of which hormone in adults?

CORE CONCEPT & DERIVATION

Excessive growth hormone secretion after epiphyseal plate closure produces periosteal bone thickening rather than longitudinal skeletal growth.

Formula / Rule / Reaction:

Hypersecretion of STH: $\begin{cases} \text{Before puberty (open epiphyses)} \Rightarrow \text{Gigantism} \\ \text{After adulthood (closed epiphyses)} \Rightarrow \text{Acromegaly} \end{cases}$

Solution:

- Hypersecretion of somatotrophic hormone (STH/GH) in adults leads to acromegaly.
- Because epiphyseal cartilages have ossified, bones can only grow appositionally, causing enlargement of the hands, feet, jaw, and facial bones.

Why other options are incorrect:

- **Option B:** Hypersecretion of TSH leads to secondary hyperthyroidism and thyrotoxicosis.
- **Option C:** ICSH (LH in males) stimulates Leydig cell testosterone secretion.
- **Option D:** FSH regulates gametogenesis and ovarian follicular development.

Question #62 Key: (A)BIOLOGY
01. Cell

Glycoproteins function as cell surface markers in which of the following biological structures?

CORE CONCEPT & DERIVATION

Cell surface glycoproteins and glycolipids serve as molecular recognition tags that define immunological identity.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Human ABO blood group antigens are oligosaccharide-protein/lipid complexes (glycoproteins and glycolipids) on erythrocyte membranes.
- Terminal sugar residues confer specific antigenic identity for immunological cross-matching.

Why other options are incorrect:

- **Option B:** Thylakoid membranes are predominantly composed of galactolipids, sulfolipids, and photosynthetic complexes.
- **Option C:** Egg yolk is rich in phospholipids and lipovitellin lipoproteins for embryonic nutrition.
- **Option D:** The myelin sheath consists of roughly 70 to 80% hydrophobic lipids (sphingomyelin and galactocerebrosides) to serve as an electrical insulator.

Question #63 Key: (B)BIOLOGY
07. Circulation / Transport

An open circulatory system with a hemocoel is found in which of the following organisms?

CORE CONCEPT & DERIVATION

In an open circulatory system, blood is not confined to continuous endothelial vessels but empties into open sinuses (hemocoel).

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Arthropods like the cockroach (*Periplaneta americana*) possess an open circulatory system.
- A 13-chambered dorsal tubular heart pumps hemolymph into the hemocoel, bathing visceral tissues directly.

Why other options are incorrect:

- **Option A:** Earthworms (annelids) have a closed circulatory system with blood confined to closed vessels and lateral aortic arches.
- **Option C:** Humans have a closed double-circuit cardiovascular system.
- **Option D:** Fish have a closed single-circuit cardiovascular system.

Question #64 Key: (C)BIOLOGY
11. Support & Movement

During skeletal muscle contraction, the troponin complex binds directly to all of the following...

CORE CONCEPT & DERIVATION

Troponin is a heterotrimeric regulatory protein complex associated with the thin actin filaments of striated muscle.

Formula / Rule / Reaction:

Troponin Subunits = Tn-C (binds Ca^{2+}) + Tn-T (binds Tropomyosin) + Tn-I (binds Actin) $\frac{1}{2}\text{O}_2 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O}; E^\circ = +0.82 \text{ V}$ (High reduction potential, low energy)

Solution:

- Troponin consists of three specialized subunits: Troponin-C (binds Ca^{2+}), Troponin-T (binds tropomyosin), and Troponin-I (binds actin to inhibit cross-bridge interaction).
- Troponin never binds directly to thick myosin filaments; thick filament heads interact with actin only when troponin moves tropomyosin away.

Why other options are incorrect:

- **Option A:** Troponin-I binds to actin to hold the regulatory complex in an inhibitory position.
- **Option B:** Troponin-T anchors the troponin complex directly to tropomyosin.
- **Option D:** Troponin-C binds calcium ions to induce the conformational change that initiates cross-bridge cycling.

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

Red blood cells of blood group A-negative can be safely transfused to a recipient with which blood group...

CORE CONCEPT & DERIVATION

Transfusion compatibility requires that donor red cells lack antigens against which the recipient possesses pre-formed or inducible plasma antibodies.

Formula / Rule / Reaction:

Donor: $\text{A}^- \Rightarrow$ Antigen A present, Rh antigen absent

Solution:

- A-negative erythrocytes carry antigen A on their cell membranes and lack the Rh(D) antigen.
- An A-positive recipient already expresses antigen A and Rh(D) antigens and carries anti-B antibodies in plasma.
- Because the donor cells lack antigen B and Rh antigens, no agglutination occurs in an A-positive recipient.

Why other options are incorrect:

- **Option A:** O-negative plasma contains anti-A and anti-B antibodies, which would attack donor antigen A and cause hemolytic transfusion reactions.
- **Option B:** O-positive plasma contains circulating anti-A antibodies.
- **Option D:** B-positive plasma contains circulating anti-A antibodies that rapidly agglutinate donor A red cells.

Question #66 Key: (C)BIOLOGY
04. Bioenergetics

Oxygen, which serves as the terminal electron acceptor in the mitochondrial electron transport...

CORE CONCEPT & DERIVATION

Electrons flow down a thermodynamic gradient through the respiratory chain toward the most electronegative carrier with the lowest free energy.

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

- Electrons pass spontaneously from carriers with lower reduction potentials (higher free energy, like NADH) to carriers with higher reduction potentials.
- Oxygen has the highest reduction potential (+0.82 V), placing it at the lowest free energy level at the bottom of the respiratory cascade.

Why other options are incorrect:

- **Option A:** High free energy states characterize upstream electron donors like NADH and FADH_2 .
- **Option B:** Oxygen is highly electronegative and chemically reactive.
- **Option D:** Oxygen is reduced to stable water, not deactivated.

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

Sensory receptors specialized for the detection of noxious or painful stimuli are known as:

CORE CONCEPT & DERIVATION

Nociceptors are free nerve endings that transduce mechanical, thermal, or chemical tissue injury into pain signals.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Nociceptors (pain receptors) respond to harmful stimuli that exceed physiological thresholds.
- They send afferent action potentials along A-delta and C fibers to the dorsal horn of the spinal cord.

Why other options are incorrect:

- **Option A:** Thermoreceptors detect non-damaging variations in temperature.
- **Option B:** Chemoreceptors detect changes in chemical concentrations (such as pH, pCO_2 , and taste/olfactory molecules).
- **Option D:** Photoreceptors (rods and cones) detect photons of visible light.

Question #68 Key: (A)BIOLOGY
07. Circulation / Transport

Cardiac muscle tissue is found exclusively in which of the following anatomical structures?

CORE CONCEPT & DERIVATION

Cardiac muscle (myocardium) is an involuntary, striated muscle tissue restricted to the muscular walls of the heart.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Cardiac muscle cells (cardiomyocytes) with intercalated discs form the myocardium of the atrial and ventricular walls.
- Blood vessels contain vascular smooth muscle, and heart valves consist of dense fibrous connective tissue.

Why other options are incorrect:

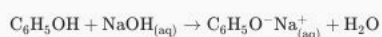
- **Option B:** The tunica media of the aorta consists of vascular smooth muscle and elastic lamellae, not cardiac muscle.
- **Option C:** Heart valves are avascular flaps of fibrous connective tissue lined by endocardium.
- **Option D:** Pulmonary arteries contain smooth muscle cells rather than striated cardiac muscle.

Question #69 Key: (C)CHEMISTRY
16. Alcohols & Phenols

Which of the following statements regarding the chemical properties of phenol is correct?

CORE CONCEPT & DERIVATION

Phenol is weakly acidic ($pK_a \approx 10$) and reacts with strong aqueous bases to form water-soluble phenoxide salts.

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

- Because the phenoxide anion is stabilized by resonance delocalization into the aromatic ring, phenol behaves as an acid toward strong alkalis like NaOH.
- It neutralizes and dissolves readily in aqueous alkaline solutions to yield soluble sodium phenoxide.

Why other options are incorrect:

- **Option A:** Phenol is roughly one million times more acidic than aliphatic alcohols ($pK_a \approx 16 - 18$).
- **Option B:** Hydrochloric acid is a strong mineral acid ($pK_a \approx -7$), far more acidic than phenol.
- **Option D:** Carboxylic acids ($pK_a \approx 4 - 5$) are stronger acids than phenol because resonance in carboxylate ions involves two electronegative oxygen atoms.

Question #70 Key: (B)CHEMISTRY
07. Equilibrium

Precipitation of an ionic solute occurs from solution when the ionic product (Formula) is:

CORE CONCEPT & DERIVATION

The solubility product constant (K_{sp}) represents the equilibrium ion concentration product of a saturated solution.

Formula / Rule / Reaction:

$$\begin{cases} Q_{sp} < K_{sp} & \text{Unsaturated (no precipitate)} \\ Q_{sp} = K_{sp} & \text{Saturated at equilibrium} \\ Q_{sp} > K_{sp} & \text{Supersaturated (precipitation occurs)} \end{cases}$$

Solution:

- When the product of constituent ion concentrations raised to their stoichiometric coefficients exceeds the solubility product constant ($Q_{sp} > K_{sp}$), the solution is supersaturated.
- Thermodynamic equilibrium is restored by the formation and precipitation of solid solute.

Why other options are incorrect:

- **Option A:** When $Q_{sp} < K_{sp}$, the solution is unsaturated and more solid can dissolve without precipitate formation.
- **Option C:** When $Q_{sp} = K_{sp}$, a dynamic dissolution-precipitation equilibrium exists without net precipitation.
- **Option D:** Precipitation is strictly dependent on the ratio of Q_{sp} to K_{sp} .

Question #71 Key: (C)

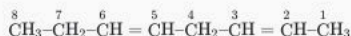
CHEMISTRY
13. Fundamental Principles of Organic Chemistry

What is the systematic IUPAC name of the hydrocarbon [Formula]?

CORE CONCEPT & DERIVATION

Alkadiene nomenclature requires choosing the longest continuous carbon chain containing both double bonds and numbering to assign the lowest locants to the double bonds.

Formula / Rule / Reaction:



Solution:

- The principal chain has 8 carbon atoms (octa-).
- Numbering from right to left gives locants 2 and 5 for the double bonds (2, 5).
- Numbering from left to right gives locants 3 and 6 (3, 6).
- Following the lowest locant rule, the correct name is 2,5-octadiene.

Why other options are incorrect:

- Option A:** 2,3-octadiene represents an allene with adjacent cumulated double bonds.
- Option B:** 2,4-octadiene represents a conjugated diene system.
- Option D:** The suffix '-yne' designates an alkyne with carbon-carbon triple bonds.

Question #72 Key: (C)

CHEMISTRY
01. StoichiometryWhich of the following statements is conceptually correct concerning the Avogadro constant (N_A)?

CORE CONCEPT & DERIVATION

The Avogadro constant defines the exact number of elementary entities contained within one mole of any chemical substance.

Formula / Rule / Reaction:

$$1 \text{ mole of any monoatomic element} = 6.022 \times 10^{23} \text{ atoms}$$

Solution:

- Neon is a monoatomic noble gas. One mole of neon contains exactly Avogadro's number of neon atoms.
- Therefore, Option C accurately describes the Avogadro constant.

Why other options are incorrect:

- Option A:** The mass of one mole of an element is its molar mass, expressed in grams per mole.
- Option B:** The Avogadro constant is a dimensionless particle count per mole, not a mass value.
- Option D:** 12 g of carbon-12 contains N_A atoms, but 12 g of any other element contains a different number of atoms.

Question #73 Key: (C)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Which of the following halogenated alkanes can exist as an optically inactive meso stereoisomer...

CORE CONCEPT & DERIVATION

A meso compound possesses two or more stereocenters and an internal plane of symmetry, making it superimposable on its mirror image and optically inactive.

Formula / Rule / Reaction:

Plane of symmetry: (2R, 3S)-2,3-dichlorobutane $\equiv$ (2S, 3R)-2,3-dichlorobutane

Solution:

- 2,3-dichlorobutane has two chiral carbon atoms (C2 and C3), each bonded to identical sets of substituents: -H, -Cl, -CH₃, and -CH(Cl)CH₃.
- In the (2R, 3S) configuration, an internal plane of symmetry bisects the C2--C3 bond, creating an optically inactive meso form.

Why other options are incorrect:

- Option A:** 2-chlorobutane has only one stereocenter and cannot form a meso isomer.
- Option B:** 2,3-dichloropentane has asymmetric substituents at C2 (methyl) and C3 (ethyl), ruling out an internal plane of symmetry.
- Option D:** 1,2-dichlorobutane has only one chiral center at C2.

Question #74 Key: (A)

CHEMISTRY
11. S & P Block Elements

Select the periodic group whose elements lose valence electrons most readily to form cations:

CORE CONCEPT & DERIVATION

Elements with the largest atomic radii and lowest first ionization energies lose electrons most readily.

Formula / Rule / Reaction:



Solution:

- Group IA (alkali metals) elements have a single valence electron in their outermost s-orbital (ns^1).
- Because of effective nuclear shielding and large atomic volumes, they possess the lowest first ionization potentials in their respective periods and readily form +1 cations.

Why other options are incorrect:

- Option B:** Group VA elements are non-metals or metalloids with high ionization energies that tend to gain or share electrons.
- Option C:** Group VIA elements (chalcogens) have high electronegativity and tend to gain two electrons.
- Option D:** Group VIIA elements (halogens) have very high electron affinities and act as strong oxidants by gaining electrons.

Question #75 Key: (A)

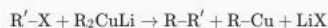
CHEMISTRY
16. Alcohols & Phenols

The coupling reaction between an alkyl halide and a lithium dialkylcuprate reagent yields:

CORE CONCEPT & DERIVATION

The Corey-House synthesis utilizes Gilman reagents (lithium dialkylcuprates) for cross-coupling with alkyl halides to form new carbon-carbon single bonds.

Formula / Rule / Reaction:



Solution:

- When an alkyl halide ($R'-X$) reacts with a lithium dialkylcuprate (Gilman reagent, R_2CuLi), nucleophilic alkyl substitution occurs.
- This forms a coupled higher alkane ($R-R'$) along with alkyl copper and lithium halide salts.

Why other options are incorrect:

- Option B:** Alkenes are synthesized via elimination reactions (dehydrohalogenation or dehalogenation), not by this organocuprate coupling.
- Option C:** Alkyl copper ($R-Cu$) is an organometallic byproduct, not the primary organic target product.
- Option D:** Alkenyl halides are starting precursors for vinylic couplings, not the product of alkyl-alkyl coupling.

Question #76 Key: (D)

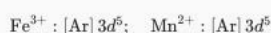
CHEMISTRY
12. Transition Elements

Which pair of transition metal cations both possess exactly five unpaired d-electrons in their ...

CORE CONCEPT & DERIVATION

Transition metal cations lose their outermost 4s electrons prior to 3d electrons during ionization.

Formula / Rule / Reaction:



Solution:

- Iron ($Z = 26$): Neutral ground state is $[Ar] 3d^6 4s^2$. Loss of three electrons yields Fe^{3+} with $[Ar] 3d^5$ (five unpaired electrons).
- Manganese ($Z = 25$): Neutral ground state is $[Ar] 3d^5 4s^2$. Loss of two electrons yields Mn^{2+} with $[Ar] 3d^5$ (five unpaired electrons).

Why other options are incorrect:

- Option A:** Fe^{2+} has a $3d^6$ configuration containing only 4 unpaired electrons.
- Option B:** Mn^{3+} has a $3d^4$ configuration containing only 4 unpaired electrons.
- Option C:** Mn^{3+} has 4 unpaired electrons while Fe^{3+} has 5.

Question #77 Key: (C)

CHEMISTRY
04. Gases

If four identical balloons are filled with different pure gases at the same temperature and pre...

CORE CONCEPT & DERIVATION

Graham's law states that the rate of gas effusion through microscopic pores is inversely proportional to the square root of its molar mass.

Formula / Rule / Reaction:

$$r \propto \frac{1}{\sqrt{M}}; \quad M(H_2) = 2, \quad M(He) = 4, \quad M(N_2) = 28, \quad M(O_2) = 32 \text{ g/mol}$$

Solution:

- Hydrogen gas (H_2) has the lowest molar mass (2 g/mol) of all gases.
- Because its molecules have the highest root-mean-square velocity, hydrogen effuses faster than helium, nitrogen, or oxygen, causing the balloon to deflate first.
- Note on board key:** Some test keys erroneously marked oxygen; according to Graham's law, hydrogen is the scientifically correct answer.

Why other options are incorrect:

- Option A:** Helium ($M = 4$ g/mol) effuses at roughly 0.71 times the rate of molecular hydrogen.
- Option B:** Oxygen ($M = 32$ g/mol) is sixteen times heavier than hydrogen and effuses four times slower.
- Option D:** Nitrogen ($M = 28$ g/mol) effuses substantially slower than hydrogen.

Question #78 Key: (B)

CHEMISTRY
11. S & P Block Elements

Which of the following chemical elements has the lowest first ionization potential?

CORE CONCEPT & DERIVATION

Ionization potential measures the energy needed to remove the most loosely bound electron from an isolated gaseous atom.

Formula / Rule / Reaction:



Solution:

- Lithium has an electron configuration of $1s^2 2s^1$.
- Its lone valence electron in the 2s subshell is shielded by the inner $1s^2$ core, resulting in a low first ionization potential of 520 kJ/mol.

Why other options are incorrect:

- Option A:** Helium has a completely filled $1s^2$ duet close to the nucleus, giving it the highest ionization potential in the periodic table (2372 kJ/mol).
- Option C:** Zinc has a relatively high ionization energy (906 kJ/mol) due to poor d-orbital shielding and a filled $4s^2$ subshell.
- Option D:** Nitrogen has an exceptionally stable, half-filled $2p^3$ subshell, requiring 1402 kJ/mol.

Question #79 Key: (A)CHEMISTRY
02. Atomic Structure

Which atomic concept was originally formulated and introduced by Niels Bohr?

CORE CONCEPT & DERIVATION

The Bohr model of the atom introduced quantization of orbital angular momentum and discrete electronic energy states.

Formula / Rule / Reaction:

$$mvr = \frac{nh}{2\pi}; \quad E_n = -\frac{13.6}{n^2} \text{ eV}$$

Solution:

- In 1913, Niels Bohr adapted Planck's quantum hypothesis to Rutherford's nuclear atom.
- He proposed that electrons revolve around the nucleus only in stationary, non-radiating, quantized energy levels (orbits).

Why other options are incorrect:

- **Option B:** Three-dimensional probability orbitals were introduced by Erwin Schrodinger via wave mechanics.
- **Option C:** Sub-orbits (elliptical subshells) were introduced by Arnold Sommerfeld.
- **Option D:** Magnetic quantum numbers were formulated by Sommerfeld and Lande to explain the Zeeman effect.

Question #80 Key: (B)CHEMISTRY
19. Macromolecules / Biochemistry

Which enzyme is clinically administered for the therapeutic treatment of acute lymphoblastic le...

CORE CONCEPT & DERIVATION

Leukemic cells lack asparagine synthetase and must acquire circulating L-asparagine from host plasma to survive.

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

- Administering the enzyme L-asparaginase hydrolyzes plasma asparagine into aspartate and ammonia.
- This starves neoplastic lymphoblasts of this amino acid, blocking protein synthesis and triggering apoptosis in leukemic cells.

Why other options are incorrect:

- **Option A:** Thrombin is a pro-coagulant serine protease that converts fibrinogen to fibrin in blood clotting.
- **Option C:** LDH-1 is a diagnostic serum cardiac biomarker for myocardial infarction, not a cancer therapeutic.
- **Option D:** Zymase is a fungal enzyme complex used in industrial alcoholic fermentation.

Question #81 Key: (D)CHEMISTRY
04. Gases

The ideal gas equation ([Formula]) can be rearranged to calculate all of the following gas pr...

CORE CONCEPT & DERIVATION

The ideal gas law describes the physical equation of state for a gas phase rather than solution concentrations.

Formula / Rule / Reaction:

$$PV = nRT \iff P = \frac{n}{V}RT = \frac{\rho}{M}RT$$

Solution:

- The ideal gas equation directly relates pressure (P), volume (V), moles (n), and absolute temperature (T).
- By substituting $n = m/M$, it calculates gas density ($\rho = PM/RT$).
- Molarity refers to moles of dissolved solute per liter of liquid solution and cannot be derived for an ideal gas phase.

Why other options are incorrect:

- **Option A:** Pressure is directly determined using $P = nRT/V$.
- **Option B:** Gas density is determined using $\rho = PM/RT$.
- **Option C:** Number of moles is directly calculated from $n = PV/RT$.

Question #82 Key: (B)CHEMISTRY
14. Hydrocarbons

During the electrophilic aromatic substitution of benzene with fuming sulfuric acid, the attack...

CORE CONCEPT & DERIVATION

Sulfonation of benzene involves a neutral, highly polar molecule as the attacking electrophile.

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

- In fuming sulfuric acid (oleum), sulfur trioxide (SO_3) is present in high concentration.
- Because the central sulfur atom in SO_3 is bonded to three strongly electronegative oxygen atoms, it carries a pronounced partial positive charge (δ^+), making it the active electrophile.

Why other options are incorrect:

- **Option A:** Sulfur dioxide (SO_2) is unreactive toward electrophilic substitution on benzene.
- **Option C:** Sulfate ion (SO_4^{2-}) is a negatively charged nucleophilic anion.
- **Option D:** Intact H_2SO_4 acts as the reaction solvent and proton donor, not the attacking electrophile.

Question #83 Key: (C)

CHEMISTRY
14. Hydrocarbons

Which of the following chemical species is classified as an electrophile rather than a nucleoph...

CORE CONCEPT & DERIVATION

A nucleophile is an electron-rich species with a lone pair or negative charge, while an electrophile is an electron-deficient species with a vacant orbital.

Formula / Rule / Reaction:

Carbocation (Electrophile) : R_3C^+ has a sextet of valence electrons

Solution:

- H_3C^+ (methylene carbocation) possesses a positively charged carbon with an incomplete valence octet (six electrons).
- Because it seeks an electron pair to complete its octet, it acts as an electrophile, not a nucleophile.

Why other options are incorrect:

- **Option A:** Propoxide ($C_3H_7O^-$) is an alkoxide anion with unshared lone pairs and negative charge, functioning as a strong nucleophile.
- **Option B:** Thiocyanate (SCN^-) is a resonance-stabilized nucleophilic anion.
- **Option D:** Ammonia (NH_3) has a lone pair of electrons on nitrogen, functioning as a neutral nucleophile.

Question #84 Key: (D)

CHEMISTRY
17. Aldehydes & Ketones

What is the systematic IUPAC name of the organic compound [Formula]?

CORE CONCEPT & DERIVATION

When an aldehyde group ($-CHO$) is directly attached to a saturated alicyclic ring, the suffix '-carbaldehyde' is appended to the full cycloalkane name.

Formula / Rule / Reaction:

Cycloalkane ring + $-CHO \Rightarrow$ Cycloalkanecarbaldehyde

Solution:

- The compound $C_6H_{11}-CHO$ consists of a saturated six-membered cyclohexane ring connected to a formyl group.
- According to IUPAC nomenclature rules, the carbon atom of the $-CHO$ group attached to a ring is not included in the ring carbon numbering; the name is formed as 'cyclohexanecarbaldehyde'.

Why other options are incorrect:

- **Option A:** Benzenecarbaldehyde (benzaldehyde) contains an unsaturated aromatic benzene ring (C_6H_5-CHO).
- **Option B:** 'Cyclohexanal' is an incorrect hybrid name violating IUPAC rules because '-al' is used only when the carbonyl carbon is part of an acyclic chain.
- **Option C:** Cyclohexyl aldehyde is a common radix functional name, not an IUPAC name.

Question #85 Key: (B)

CHEMISTRY
07. Equilibrium

A solution that resists significant changes in its hydrogen ion concentration ([Formula]) upo...

CORE CONCEPT & DERIVATION

Buffer solutions consist of a conjugate acid-base pair that neutralizes small added quantities of H^+ or OH^- ions.

Formula / Rule / Reaction:

$$pH = pK_a + \log \left(\frac{[\text{Conjugate Base}]}{[\text{Weak Acid}]} \right)$$

Solution:

- A buffer system (such as an acetic acid and sodium acetate mixture) consumes added H^+ via the acetate base and added OH^- via the weak acid.
- This common-ion buffering mechanism keeps the solution pH relatively stable.

Why other options are incorrect:

- **Option A:** An unbuffered acidic solution changes pH upon the introduction of exogenous bases.
- **Option C:** An unbuffered basic solution shifts pH upon the introduction of acids.
- **Option D:** A supersaturated solution contains excess dissolved solute beyond equilibrium limits, unrelated to pH buffering.

Question #86 Key: (A)

CHEMISTRY
02. Atomic Structure

What is the ground-state electronic configuration of a neutral Carbon atom ([Formula])?

CORE CONCEPT & DERIVATION

Electrons occupy atomic subshells in order of increasing energy according to the Aufbau principle, Pauli exclusion principle, and Hund's rule.

Formula / Rule / Reaction:

$$\text{Aufbau Order: } 1s \rightarrow 2s \rightarrow 2p; \quad Z = 6 \Rightarrow 1s^2 2s^2 2p_x^1 2p_y^1 2p_z^0$$

Solution:

- Carbon has an atomic number of 6.
- Two electrons fill the $1s$ orbital, two fill the $2s$ orbital, and the remaining two enter separate $2p$ orbitals with parallel spins, giving $1s^2 2s^2 2p^2$.

Why other options are incorrect:

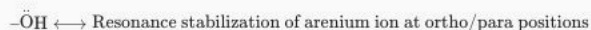
- **Option B:** $1s^2 2s^2 2p^4$ is the configuration of oxygen ($Z = 8$).
- **Option C:** This configuration corresponds to magnesium ($Z = 12$) with an improperly written subshell filling.
- **Option D:** This represents sulfur ($Z = 16$).

Question #87 Key: (C)CHEMISTRY
16. Alcohols & Phenols

Phenol undergoes electrophilic aromatic substitution much faster than benzene. This enhanced re...

CORE CONCEPT & DERIVATION

Substituent groups with unshared lone pairs on the atom attached directly to the aromatic ring delocalize electron density into the ring through resonance.

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

- The oxygen atom in the $-\text{OH}$ group donates a lone pair into the conjugated π -system of the ring via a strong mesomeric ($+M$) or resonance effect.
- This increases the electron density of the benzene ring and stabilizes the carbocation intermediate during electrophilic attack, activating the ring.
- Note on board key:* Some answer keys referenced hydrogen bonding, but the standard chemical explanation recognized in textbooks is the strong mesomeric ($+M$) resonance effect.

Why other options are incorrect:

- Option A:** Hydrogen bonding influences physical properties (such as boiling point and water solubility), but does not activate the ring toward electrophiles.
- Option B:** The inductive effect of electronegative oxygen is electron-withdrawing ($-I$), which would deactivate the ring if acting alone.
- Option D:** The hydroxyl group exhibits an electron-donating ($+M$) effect, not an electron-withdrawing ($-M$) effect.

Question #88 Key: (D)CHEMISTRY
17. Aldehydes & Ketones

What is the correct order of decreasing reactivity of carbonyl compounds toward nucleophilic ad...

CORE CONCEPT & DERIVATION

Nucleophilic attack on a carbonyl carbon is facilitated by high electrophilic partial positive charge (δ^+) and minimal steric hindrance.

Formula / Rule / Reaction:

$$\text{Reactivity} \propto \frac{1}{\text{Steric Hindrance}} \propto \frac{1}{+I / +R \text{ Electron Donation}}$$

Solution:

- Benzaldehyde ($\text{C}_6\text{H}_5\text{CHO}$) is an aldehyde with a small hydrogen atom on the carbonyl group, making it less sterically hindered and more reactive than ketones.
- Acetophenone ($\text{C}_6\text{H}_5\text{COCH}_3$) has one bulky phenyl ring and one electron-donating methyl group that decreases the electrophilicity of the carbonyl carbon.
- Benzophenone ($\text{C}_6\text{H}_5\text{COC}_6\text{H}_5$) has two bulky phenyl rings that generate significant steric hindrance and resonance stabilization, making it the least reactive.
- Order: Benzaldehyde > Acetophenone > Benzophenone.

Why other options are incorrect:

- Option A:** Incorrectly ranks the diaryl ketone (benzophenone) as more reactive than the alkyl-aryl ketone (acetophenone).
- Option B:** Incorrectly places the least reactive ketone (benzophenone) as the most reactive.
- Option C:** Incorrectly places ketones ahead of the more reactive aldehyde.

Question #89 Key: (C)

CHEMISTRY
12. Transition Elements

The general valence shell electronic configuration of the d-block transition elements is repres...

CORE CONCEPT & DERIVATION

Transition metals are characterized by progressive filling of the penultimate $(n-1)d$ subshell while possessing 0 to 2 electrons in the outermost ns subshell.

Formula / Rule / Reaction:

$$\text{Valence Configuration: } (n-1)d^{1-10}ns^{0-2}$$

Solution:

- Most transition elements have an ns^2 outer configuration (e.g., Sc : $3d^14s^2$).
- Anomalous configurations driven by subshell stability include ns^1 (e.g., Cr : $3d^54s^1$, Cu : $3d^{10}4s^1$) and ns^0 (e.g., Pd : $4d^{10}5s^0$).
- Thus, the general formula is $(n-1)d^{1-10}ns^{0-2}$.

Why other options are incorrect:

- Option A:** Omits elements with ns^1 or ns^0 configurations like copper, chromium, and palladium.
- Option B:** Erroneously assigns the principal quantum number $n-1$ to the outermost s-subshell.
- Option D:** Fails to account for the energy difference where the d-orbital belongs to the penultimate shell ($n-1$).

Question #90 Key: (A)

CHEMISTRY
01. Stoichiometry

On the microscopic atomic scale, atomic mass (weight) is conventionally expressed in which unit...

CORE CONCEPT & DERIVATION

Atomic mass unit (amu or Dalton) is a standard unit of mass defined relative to the mass of an unbound carbon-12 atom.

Formula / Rule / Reaction:

$$1 \text{ amu} = \frac{1}{12} \times m(^{12}\text{C}) \approx 1.66054 \times 10^{-27} \text{ kg}$$

Solution:

- Individual atomic masses are too small to be conveniently measured in macroscopic units like grams or kilograms.
- The atomic mass unit (amu) scales atomic masses relative to carbon-12 (assigned a mass of exactly 12 amu).

Why other options are incorrect:

- Option B:** Grams are macroscopic SI-derived units used for molar masses rather than individual atoms.
- Option C:** Kilograms are the base SI macroscopic unit of mass.
- Option D:** A mole is a unit of chemical amount (particle count), not mass.

Question #91 Key: (A)

CHEMISTRY
10. Electrochemistry

What is the oxidation state of chlorine in an isolated molecule of diatomic chlorine gas (For...

CORE CONCEPT & DERIVATION

By convention, the oxidation state of any element in its native, uncombined elemental form is zero.

Formula / Rule / Reaction:

$$\text{Homodiatom covalent bond (Cl-Cl)} \Rightarrow \Delta\chi = 0 \Rightarrow \text{Oxidation Number} = 0$$

Solution:

- In Cl_2 , two identical chlorine atoms share an electron pair equally without electronegativity difference ($\Delta\chi = 0$).
- Because there is no net transfer or shift of electron density, each chlorine atom has an oxidation number of 0.

Why other options are incorrect:

- Option B:** Chlorine exhibits a +1 oxidation state in hypochlorite compounds like HOCl.
- Option C:** Chlorine exhibits a -1 oxidation state in ionic chlorides like NaCl and covalent HCl.
- Option D:** Chlorine does not form a stable -2 oxidation state.

Question #92 Key: (B)

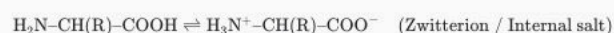
CHEMISTRY
13. Fundamental Principles of Organic Chemistry

A dipolar ion carrying separated positive and negative electrical charges on the same molecule ...

CORE CONCEPT & DERIVATION

Amino acids contain both a basic amino group and an acidic carboxyl group, undergoing intramolecular proton transfer in aqueous solution.

Formula / Rule / Reaction:



Solution:

- The basic amino group ($-\text{NH}_2$) captures a proton from the carboxyl group ($-\text{COOH}$).
- This produces a dipolar ion known as a zwitterion or internal salt, carrying an ammonium cation ($-\text{NH}_3^+$) and a carboxylate anion ($-\text{COO}^-$).

Why other options are incorrect:

- Option A:** A double salt (like Mohr's salt or alum) consists of two distinct crystalline salts that dissociate into individual ions in water.
- Option C:** A basic salt forms through incomplete neutralization of a polyhydroxy base with an acid.
- Option D:** An acidic salt contains replaceable hydrogen atoms from incomplete neutralization of a polybasic acid (e.g., NaHCO_3).

Question #93 Key: (B)CHEMISTRY
11. S & P Block Elements

Which of the following alkali metal (Group IA) hydroxides has the lowest aqueous solubility at ...

CORE CONCEPT & DERIVATION

Dissolution of an ionic solid depends on the balance between crystal lattice energy and ion hydration energy.

Formula / Rule / Reaction:

$$\Delta H_{\text{solution}} = \text{Lattice Energy} - \text{Hydration Energy}$$

Solution:

- Lithium has a small ionic radius (Li^+).
- When paired with the small hydroxide ion (OH^-), it forms a crystalline lattice with very high lattice energy that is not compensated by hydration enthalpy.
- Consequently, LiOH has the lowest aqueous solubility among all Group IA hydroxides.

Why other options are incorrect:

- Option A:** NaOH has lower lattice energy and dissolves exothermically with high solubility.
- Option C:** KOH is extremely deliquescent and highly soluble in water.
- Option D:** RbOH contains large Rb^+ cations with low lattice energy, making it readily soluble.

Question #94 Key: (A)CHEMISTRY
03. Chemical Bonding

During the spontaneous formation of a stable covalent or ionic chemical bond between isolated a...

CORE CONCEPT & DERIVATION

Chemical bond formation is an exothermic process driven by electrostatic attraction that lowers the potential energy of participating atoms.

Formula / Rule / Reaction:

$$\Delta H_{\text{bond formation}} < 0 \implies \text{Potential energy decreases to a stable minimum}$$

Solution:

- As two atoms approach, attractive forces between their nuclei and valence electrons overcome internuclear repulsions.
- The potential energy decreases until it reaches an energy minimum at the equilibrium bond distance, releasing bond energy.

Why other options are incorrect:

- Option B:** An increase in potential energy corresponds to bond dissociation (endothermic process).
- Option C:** Potential energy must change as electron clouds overlap and rearrange.
- Option D:** As atoms approach from infinity, attractive forces monotonically decrease the potential energy until reaching the bond distance.

Question #95 Key: (A)CHEMISTRY
05. Liquids

In 1825, Michael Faraday first isolated and discovered benzene from the condensate of an illumi...

CORE CONCEPT & DERIVATION

Benzene was historically discovered by pyrolysis and thermal cracking of whale or vegetable illuminating oil.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Michael Faraday isolated benzene in 1825 from an oily condensate collected from illuminating gas produced by the destructive distillation (pyrolysis) of whale/vegetable oils.
- He originally named the clear liquid compound 'bicarburet of hydrogen'.

Why other options are incorrect:

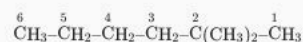
- Option B:** Fractional distillation of petroleum was developed much later as an industrial refining technique.
- Option C:** Isolation of benzene from coal tar via fractional distillation was achieved in 1845 by Charles Mansfield and A. W. von Hofmann.
- Option D:** Vacuum distillation of wood yields methanol (wood spirit) and acetic acid, not the illuminating gas condensate studied by Faraday.

Question #96 Key: (D)CHEMISTRY
13. Fundamental Principles of Organic Chemistry

What is the systematic IUPAC name of the branched alkane [Formula] ?

CORE CONCEPT & DERIVATION

Alkane nomenclature requires identifying the longest continuous carbon chain and numbering from the end closest to substituents.

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

- Expanding the condensed structure gives:
 $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{C}(\text{CH}_3)_2-\text{CH}_3$.
- The longest continuous chain contains 6 carbon atoms (hexane).
- Numbering from the right places two methyl groups at carbon-2, giving the lowest set of locants (2,2 rather than 5,5).
- The IUPAC name is 2,2-dimethylhexane.

Why other options are incorrect:

- Option A:** 2-methylhexane contains only one branch and seven total carbons.
- Option B:** Neo-octane is a non-systematic common name.
- Option C:** 5,5-dimethylhexane results from numbering the main chain from the wrong end.

Question #97 Key: (C)CHEMISTRY
01. Stoichiometry

In a chemical reaction, the reactant that is completely consumed first and limits the amount of...

CORE CONCEPT & DERIVATION

Stoichiometric product yield is dictated by the reactant present in the smallest molar ratio relative to the balanced equation.

Formula / Rule / Reaction:

$$\text{Theoretical Yield} = f(\text{Moles of Limiting Reactant})$$

Solution:

- The limiting reactant is completely consumed before other reactants in the reaction mixture.
- Because no further reaction can occur without it, it determines the maximum theoretical yield of product.

Why other options are incorrect:

- Option A:** 'Active reactant' is not a standard stoichiometric term.
- Option B:** The excess reactant remains unreacted in the vessel after the limiting reactant is completely consumed.
- Option D:** A catalyst accelerates the reaction without being consumed as a stoichiometric reactant.

Question #98 Key: (B)CHEMISTRY
12. Transition Elements

The spatial geometric arrangement of ligands in a coordination complex is primarily determined ...

CORE CONCEPT & DERIVATION

Valence Bond and Crystal Field theories correlate coordination geometries with specific metal orbital hybridization schemes.

Formula / Rule / Reaction:

$$sp^3 \Rightarrow \text{Tetrahedral}; \quad dsp^2 \Rightarrow \text{Square Planar}; \quad d^2sp^3/sp^3d^2 \Rightarrow \text{Octahedral}$$

Solution:

- The spatial geometry of a complex (such as linear, square planar, tetrahedral, or octahedral) is determined by the hybridization of the central metal ion's atomic orbitals.
- Hybridized orbitals project toward coordinates in space to form directional coordinate bonds with donor ligand pairs.

Why other options are incorrect:

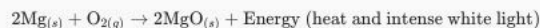
- Option A:** Chelation enhances thermodynamic stability (the chelate effect) but does not determine basic coordination geometry.
- Option C:** Counter ions reside outside the primary coordination sphere and do not alter internal ligand coordination geometry.
- Option D:** Donor electronegativity affects spectrochemical ligand field strength, while spatial orientation is dictated by metal hybridization.

Question #99 Key: (D)CHEMISTRY
11. S & P Block Elements

When magnesium metal is ignited in air, it burns with a characteristic and brilliant flame of w...

CORE CONCEPT & DERIVATION

Highly exothermic oxidation of magnesium vaporizes atoms that emit intense broad-spectrum radiation upon returning to lower electronic states.

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

- Igniting magnesium in air produces a reaction reaching temperatures above 3000 K.
- Thermal incandescence of solid magnesium oxide particles together with electronic transitions yields an intense, blinding white flame across the entire visible spectrum.

Why other options are incorrect:

- Option A:** Blue flames are typical of burning non-metals like sulfur or burning carbon monoxide.
- Option B:** Violet/lilac flames are characteristic of potassium salts in flame tests.
- Option C:** Yellow flames are characteristic of burning sodium salts.

Question #100 Key: (D)CHEMISTRY
10. Electrochemistry

According to the standard electrochemical series, which of the following metal cations possesses...

CORE CONCEPT & DERIVATION

The standard reduction potential (E°) indicates the relative tendency of a chemical species to acquire electrons and be reduced.

Formula / Rule / Reaction:

$$E^\circ(\text{Ba}^{2+}) = -2.91 \text{ V}; \quad E^\circ(\text{Ca}^{2+}) = -2.87 \text{ V}; \quad E^\circ(\text{Mg}^{2+}) = -2.37 \text{ V}; \quad E^\circ(\text{Al}^{3+}) = -1.66 \text{ V}$$

Solution:

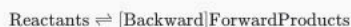
- As one descends the electrochemical series from alkali metals to less reactive metals, the reduction potentials become less negative (increase toward zero).
- Among the given choices, Al^{3+} has an E° value of -1.66 V , which is the highest (least negative) value, meaning it reduces most readily among the four ions.

Why other options are incorrect:

- Option A:** Barium ion has a very low reduction potential of -2.91 V .
- Option B:** Calcium ion has a reduction potential of -2.87 V .
- Option C:** Magnesium ion has a reduction potential of -2.37 V , more negative than that of aluminum.

Question #101 Key: (C)CHEMISTRY
07. Equilibrium*Why does a reversible chemical reaction not proceed to completion?***CORE CONCEPT & DERIVATION**

A chemical reaction is reversible when the products formed possess sufficient chemical reactivity to react together and regenerate the original reactants.

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

- In a reversible reaction, dynamic equilibrium is established because the forward and reverse reactions occur at equal rates.
- The reaction never reaches completion because the products remain chemically reactive, continually recombining to reform reactants.
- Note on board key:* Some unofficial transcripts marked Option B; standard textbooks and chemical principles confirm that product reactivity (Option C) defines reversibility.

Why other options are incorrect:

- Option A:** Reactant reactivity initiates the forward reaction, but does not explain why the reaction reverses.
- Option B:** Completely stable reactants would not react in the forward direction at all.
- Option D:** If products were completely inert, they could not react backward, driving the reaction irreversibly to completion.

Question #102 Key: (C)CHEMISTRY
06. Solids*Which of the following structural characteristics is true for amorphous solids?***CORE CONCEPT & DERIVATION**

Amorphous solids lack long-range translational periodicity but can exhibit short-range structural order known as crystallites.

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

- Amorphous solids (such as glass and polymers) lack the repetitive three-dimensional lattice of crystalline solids.
- However, small localized regions can exhibit short-range order; these micro-ordered domains are termed crystallites.

Why other options are incorrect:

- Option A:** Perfect long-range periodic order is the defining hallmark of crystalline solids.
- Option B:** Amorphous solids soften gradually over a temperature range rather than exhibiting sharp melting points.
- Option D:** Amorphous solids break with conchoidal, irregular fractures rather than cleavage along crystallographic planes.

Question #103 Key: (C)CHEMISTRY
18. Carboxylic Acids*Which of the following functional groups is present in ethyl acetate?***CORE CONCEPT & DERIVATION**

Esters are carboxylic acid derivatives characterized by an acyl group bonded to an alkoxy moiety.

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

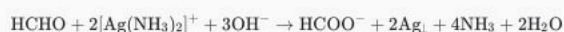
- Ethyl acetate (ethyl ethanoate) is formed by the Fischer esterification of acetic acid with ethanol.
- Its structure contains the characteristic ester functional linkage (-COO-).

Why other options are incorrect:

- Option A:** Aldehydes contain a carbonyl group bonded to at least one hydrogen atom (-CHO).
- Option B:** Carboxylic acids contain a free carboxyl group (-COOH).
- Option D:** Ethers contain an oxygen atom bonded between two alkyl groups (R-O-R') without a carbonyl carbon.

Question #104 Key: (A)CHEMISTRY
17. Aldehydes & Ketones*Which of the following organic compounds reduces Tollens' reagent to produce a metallic silver ...***CORE CONCEPT & DERIVATION**

Tollens' reagent (ammoniacal silver nitrate) is a mild oxidizing agent that selectively oxidizes aldehydes to carboxylate salts while being reduced to metallic silver.

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

- Methanal (formaldehyde) is an aldehyde and is readily oxidized by Tollens' reagent.
- The diamminesilver(I) complex ion is reduced, depositing elemental silver as a shiny mirror on the inner test tube wall.

Why other options are incorrect:

- Option B:** Acetic acid is a carboxylic acid and does not undergo oxidation with Tollens' reagent.
- Option C:** Ethyl alcohol is a primary alcohol and is not oxidized by mild reagents like Tollens' reagent.
- Option D:** Acetone is a ketone that lacks a formyl hydrogen atom, making it resistant to oxidation under these conditions.

Question #105 Key: (B)

CHEMISTRY
08. Reaction Kinetics

A catalyst accelerates the rate of a chemical reaction primarily by:

CORE CONCEPT & DERIVATION

A catalyst provides an alternative reaction pathway with a lower activation energy, increasing the fraction of effective collisions.

Formula / Rule / Reaction:

$$k = Ae^{-E_a/RT}; \quad E'_a < E_a \implies \text{Fraction } e^{-E'_a/RT} \text{ increases}$$

Solution:

- By lowering the activation energy barrier (E_a), a catalyst enables a larger fraction of colliding particles to possess energy equal to or greater than the new threshold.
- This increases the rate of successful product-forming collisions per unit time.

Why other options are incorrect:

- Option A:** Total collision frequency is governed by temperature and concentration; a catalyst alters the energetic threshold rather than collision count.
- Option C:** A catalyst does not alter the thermodynamic enthalpy of reaction (ΔH) or equilibrium position.
- Option D:** A catalyst does not change the physical concentration of the starting reactants.

Question #106 Key: (C)

CHEMISTRY
05. Liquids

Which structural isomer of pentane ([Formula]) has the lowest boiling point?

CORE CONCEPT & DERIVATION

Increased branching in isomeric alkanes produces a more compact, spherical molecular shape, reducing surface contact area and weakening London dispersion forces.

Formula / Rule / Reaction:

Boiling points: n -Pentane (36.1°C) > Isopentane (27.8°C) > Neopentane (9.5°C)

Solution:

- Neopentane (2,2-dimethylpropane) has a highly symmetrical, nearly spherical tetrahedral geometry.
- This compact structure minimizes intermolecular surface area, leading to the weakest van der Waals attractions and the lowest boiling point (9.5°C) among the pentane isomers.

Why other options are incorrect:

- Option A:** n -Pentane is an unbranched linear alkane with the largest contact surface area, giving it the highest boiling point (36.1°C).
- Option B:** Isopentane has only one branch, resulting in stronger dispersion forces than neopentane (boiling point 27.8°C).
- Option D:** 2-Methylbutane is the systematic IUPAC name for isopentane.

Question #107 Key: (D)

CHEMISTRY
08. Reaction Kinetics

The rate of a chemical reaction when the concentration of each reactant is taken as unity (1 mo...)

CORE CONCEPT & DERIVATION

The specific rate constant is numerically identical to the reaction rate under standard unit concentration conditions.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^x[B]^y; \quad \text{When } [A] = [B] = 1 \text{ mol/dm}^3 \implies \text{Rate} = k$$

Solution:

- From the differential rate law, when all reactant concentrations are set to unity (1 M), the reaction rate becomes numerically equal to k .
- This proportionality parameter is formally defined as the specific rate constant or velocity constant.

Why other options are incorrect:

- Option A:** The Arrhenius factor (A) represents the pre-exponential collision frequency parameter.
- Option B:** The equilibrium constant (K_{eq}) is the ratio of product to reactant concentrations at chemical equilibrium.
- Option C:** Molecularity is the number of reacting particles that collide simultaneously in an elementary step.

Question #108 Key: (C)

CHEMISTRY
17. Aldehydes & Ketones

Dry heating (pyrolysis) of solid calcium acetate yields which of the following organic compound...

CORE CONCEPT & DERIVATION

Thermal dry distillation of the calcium salts of carboxylic acids causes decarboxylation and condensation to produce symmetrical ketones.

Formula / Rule / Reaction:



Solution:

- When anhydrous calcium acetate is heated dry, it undergoes thermal decomposition.
- Calcium carbonate precipitates while acetone (propan-2-one) distills off as a volatile vapor.

Why other options are incorrect:

- Option A:** Acetaldehyde is formed by the dry distillation of a mixture of calcium acetate and calcium formate.
- Option B:** Acetic acid is produced by treating the salt with a mineral acid, not by dry pyrolysis.
- Option D:** Ethane is formed via Kolbe's electrolytic decarboxylation of aqueous acetate solutions.

Question #109 Key: (A)

CHEMISTRY
04. Gases

According to Charles's law, the theoretical volume of a given mass of an ideal gas drops to zero...

CORE CONCEPT & DERIVATION

Charles's law states that the volume of an ideal gas at constant pressure decreases linearly by $1/273.15$ of its volume at 0°C for every Celsius degree drop.

Formula / Rule / Reaction:

$$V_t = V_0 \left(1 + \frac{t}{273}\right); \quad V_t = 0 \implies t = -273.15^\circ\text{C} \text{ (0 K)}$$

Solution:

- Extrapolating the volume-temperature isobar to zero volume intersects the temperature axis at absolute zero.
- On the Celsius temperature scale, this corresponds to -273.15°C (commonly rounded to -273°C).

Why other options are incorrect:

- Option B:** $+273^\circ\text{C}$ corresponds to 546 K, where the gas volume would double relative to its volume at 0°C .
- Option C:** 100°C is the normal boiling point of water at standard atmospheric pressure.
- Option D:** At 0°C (273 K), an ideal gas occupies a standard molar volume of 22.414 dm^3 .

Question #110 Key: (D)

CHEMISTRY
16. Alcohols & Phenols

Lucas reagent, used to distinguish primary, secondary, and tertiary alcohols, consists of a mix...

CORE CONCEPT & DERIVATION

The Lucas test distinguishes alcohols based on the rate of formation of an insoluble alkyl chloride via a carbocation intermediate.

Formula / Rule / Reaction:



Solution:

- Lucas reagent is an equimolar solution of anhydrous zinc chloride (a Lewis acid catalyst) in concentrated hydrochloric acid.
- Tertiary alcohols react immediately to form oily cloudiness, secondary alcohols react within 5 to 10 minutes, and primary alcohols show no turbidity at room temperature.

Why other options are incorrect:

- Option A:** Aluminum chloride is a Lewis acid used in Friedel-Crafts alkylation, not in the Lucas reagent.
- Option B:** Concentrated hydrochloric acid alone lacks the Lewis acid catalyst required to coordinate with the alcohol oxygen.
- Option C:** Anhydrous zinc chloride alone does not supply the chloride nucleophile.

Question #111 Key: (C)

CHEMISTRY
09. Thermochemistry

The Born-Haber cycle represents an application of Hess's law primarily used to calculate the:

CORE CONCEPT & DERIVATION

Lattice energy cannot be measured directly by experiment; it is determined indirectly by summing thermochemical cycle steps using Hess's law.

Formula / Rule / Reaction:

$$\Delta H_f^\circ = \Delta H_{\text{sub}} + \text{IE} + \frac{1}{2}\Delta H_{\text{diss}} + \text{EA} + U_{\text{lattice}}$$

Solution:

- The Born-Haber cycle breaks down the formation of an ionic crystal from its constituent elements into individual thermochemical steps.
- By inserting measured enthalpies of sublimation, ionization, dissociation, and electron affinity, the crystal lattice energy (U) is calculated.

Why other options are incorrect:

- Option A:** Enthalpy of combustion is measured experimentally using a bomb calorimeter.
- Option B:** Covalent solids do not possess ionic lattice energies defined by electrostatic ion packing.
- Option D:** Ionization energies are measured directly using photoelectron spectroscopy.

Question #112 Key: (D)

CHEMISTRY
02. Atomic Structure

Why must two electrons occupying the same atomic orbital possess opposite spins?

CORE CONCEPT & DERIVATION

The Pauli exclusion principle mandates that two electrons in the same orbital must have antiparallel spin quantum numbers ($m_s = +1/2$ and $-1/2$).

Formula / Rule / Reaction:

$$\mu_s = -g_s \frac{e}{2m} S; \quad \text{Net spin magnetic moment for paired electrons: } \sum \mu_s = 0$$

Solution:

- Spinning electrons act as tiny magnetic dipoles.
- When two electrons occupy the same spatial orbital, opposite spins produce opposing magnetic dipole moments that cancel out, reducing magnetic and electrostatic repulsion to stabilize the orbital.

Why other options are incorrect:

- Option A:** Electrons in quantum mechanical orbitals do not experience mechanical friction.
- Option B:** Antiparallel spins cancel net spin angular momentum ($S = 0$), rather than doubling it.
- Option C:** Spin orientation does not alter or neutralize the fundamental negative electric charge of an electron.

Question #113 Key: (B)

CHEMISTRY
05. Liquids

The dynamic viscosity of a liquid decreases significantly with an increase in which parameter?

CORE CONCEPT & DERIVATION

Liquid viscosity is governed by intermolecular cohesive forces that are overcome by thermal kinetic energy.

Formula / Rule / Reaction:

$$\eta = Ae^{E_a/RT}; \quad T \uparrow \Rightarrow \eta \downarrow$$

Solution:

- Increasing the temperature increases the average kinetic energy of the liquid molecules.
- This added energy overcomes intermolecular cohesive attractions (such as hydrogen bonding and dipole-dipole forces), allowing molecular layers to slide past one another more easily and lowering viscosity.

Why other options are incorrect:

- Option A:** Higher molecular mass increases molecular size and chain entanglements, raising viscosity.
- Option C:** Increasing pressure compresses molecules closer together, which slightly increases viscosity.
- Option D:** Stronger intermolecular forces restrict molecular movement and increase liquid viscosity.

Question #114 Key: (B)

CHEMISTRY
02. Atomic Structure

As the value of the principal quantum number (n) increases, the radial size of an s-orbital...

CORE CONCEPT & DERIVATION

The principal quantum number (n) determines the main electron energy level and the radial distance of the electron cloud from the nucleus.

Formula / Rule / Reaction:

$$r_n \propto \frac{n^2}{Z}; \quad \text{Radial probability peak shifts to larger radii as } n \text{ increases}$$

Solution:

- Higher values of n correspond to higher electronic energy shells located farther from the nucleus.
- Consequently, the boundary surface of a $2s$ orbital is larger than that of a $1s$ orbital, and a $3s$ orbital is larger than a $2s$ orbital.

Why other options are incorrect:

- Option A:** Orbital size never contracts with increasing principal energy level.
- Option C:** Only the orbital angular momentum quantum number ($l = 0$, spherical symmetry) remains unchanged, not the orbital radius.
- Option D:** Radial dimensions increase monotonically with n .

Question #115 Key: (B)

CHEMISTRY
03. Chemical Bonding

Which of the following is classified as a secondary intermolecular interaction rather than a primary?

CORE CONCEPT & DERIVATION

Primary bonds involve valence electron sharing or transfer within molecules, whereas secondary bonds are weaker intermolecular electrostatic attractions.

Formula / Rule / Reaction:

Primary Bonds: 100 – 1000 kJ/mol; Hydrogen Bonds: 10 – 40 kJ/mol

Solution:

- Ionic, covalent, and coordinate covalent bonds are primary intramolecular bonds that hold atoms together within a chemical unit.
- Hydrogen bonding is a secondary dipole-dipole attraction that operates between separate molecules or remote segments of a macromolecule.

Why other options are incorrect:

- Option A:** Ionic bonds are primary bonds formed by complete valence electron transfer between electropositive and electronegative atoms.
- Option C:** Dative bonds are primary covalent bonds where both shared bonding electrons originate from a single donor atom.
- Option D:** Covalent bonds are primary bonds formed by electron pair sharing.

Question #116 Key: (C)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Which of the following organic compounds contains sp -hybridized carbon atoms?

CORE CONCEPT & DERIVATION

Carbon atoms involved in a triple bond use one s - and one p -orbital to form two linear sp hybrid orbitals with a 180° bond angle.

Formula / Rule / Reaction:



Solution:

- 2-Butyne contains an internal carbon-carbon triple bond ($-\text{C}\equiv\text{C}-$).
- Each central triply bonded carbon forms one σ -bond and two π -bonds, requiring sp hybridization.

Why other options are incorrect:

- Option A:** Benzene contains six equivalent sp^2 -hybridized ring carbons.
- Option B:** 1-Butene contains sp^2 alkene carbons and sp^3 alkane carbons, but no sp carbons.
- Option D:** 1-Pentene contains sp^2 and sp^3 carbons without a triple bond.

Question #117 Key: (D)

CHEMISTRY
06. Solids

Which of the following substances is classified as an amorphous solid rather than a crystalline...

CORE CONCEPT & DERIVATION

Amorphous solids consist of disordered, tangled polymer chains that lack long-range three-dimensional lattice symmetry.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Rubber consists of cross-linked polyisoprene chains that are coiled and randomly oriented.
- Because it lacks a periodic crystal lattice and cleaves irregularly, rubber is an amorphous solid.

Why other options are incorrect:

- **Option A:** Copper sulfate forms a triclinic crystalline hydrate ($\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$).
- **Option B:** Sugar forms well-defined monoclinic molecular crystals.
- **Option C:** Sodium chloride forms a face-centered cubic ionic crystal lattice.

Question #118 Key: (A)

CHEMISTRY
03. Chemical Bonding

In standard SI chemical thermodynamics, bond energy is conventionally expressed in:

CORE CONCEPT & DERIVATION

Bond enthalpy is defined as the energy required to break one mole of a specific covalent bond in gaseous molecules under standard conditions.

Formula / Rule / Reaction:

$$\text{Bond Dissociation Enthalpy: Units} = \text{kJ} \cdot \text{mol}^{-1}$$

Solution:

- Bond energies quantify bond strength on a molar basis.
- The standard SI-derived unit is kilojoules per mole (kJ/mol).

Why other options are incorrect:

- **Option B:** Calorie is an older metric unit not used in the modern SI framework.
- **Option C:** Joules without the molar denominator represent absolute energy rather than molar bond energy.
- **Option D:** Volt is the derived SI unit of electric potential difference.

Question #119 Key: (C)

CHEMISTRY
14. Hydrocarbons

The resonance hybrid structure of benzene is more stable than the hypothetical 1,3,5-cyclohexatriene...

CORE CONCEPT & DERIVATION

Resonance energy is the difference in enthalpy between a resonance-stabilized hybrid molecule and its most stable hypothetical contributing Lewis structure.

Formula / Rule / Reaction:

$$\text{Resonance Energy} = \Delta H_{\text{calc}} - \Delta H_{\text{exp}} = 358.5 - 208.0 = 150.5 \text{ kJ/mol}$$

Solution:

- The theoretical heat of hydrogenation for hypothetical 1,3,5-cyclohexatriene with three localized double bonds is $3 \times (-119.5) = -358.5 \text{ kJ/mol}$.
- The experimental heat of hydrogenation of benzene is only -208.0 kJ/mol .
- The difference of 150.5 kJ/mol represents the resonance stabilization energy of the delocalized π -electron ring.

Why other options are incorrect:

- **Option A:** 358.5 kJ/mol is the calculated heat of hydrogenation of hypothetical cyclohexatriene.
- **Option B:** 208.0 kJ/mol is the measured experimental heat of hydrogenation of benzene.
- **Option D:** 231.5 kJ/mol is an incorrect numerical value.

Question #120 Key: (A)

CHEMISTRY
19. Macromolecules / Biochemistry

The primary structural feature linking individual amino acid residues together in proteins is t...

CORE CONCEPT & DERIVATION

Proteins are linear heteropolymers formed by condensation reactions between the α -amino group of one amino acid and the α -carboxyl group of another.

Formula / Rule / Reaction:



Solution:

- During ribosomal translation, condensation between adjacent amino acids creates an amide bond (peptide bond, $-\text{CO}-\text{NH}-$).
- This repeating linkage forms the polypeptide backbone of all proteins.

Why other options are incorrect:

- **Option B:** Glycosidic bonds link monosaccharide units in carbohydrates.
- **Option C:** Ester bonds join glycerol to fatty acids in neutral lipids.
- **Option D:** Ether linkages are found in diether archaeal membrane lipids.

Question #121 Key: (B)CHEMISTRY
18. Carboxylic Acids

Acetic acid is a much weaker acid in aqueous solution than sulfuric acid because:

CORE CONCEPT & DERIVATION

Acid strength is governed by the extent of electrolytic dissociation and the equilibrium position in water.

Formula / Rule / Reaction:

$$\alpha = \sqrt{\frac{K_a}{C}}; \text{ Weak acids exhibit } \alpha \ll 1$$

Solution:

- Sulfuric acid (H_2SO_4) is a strong mineral acid that ionizes completely in dilute aqueous solution (degree of ionization $\alpha \approx 1$).
- Acetic acid (CH_3COOH) ionizes only partially (typically less than 1.3% in a 0.1 M solution), making it a weak acid.

Why other options are incorrect:

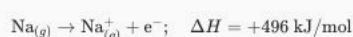
- Option A:** Thermal decomposition is unrelated to standard room-temperature acid dissociation constants.
- Option C:** All organic carboxylic acids contain a carboxyl group; this alone does not explain relative ionization differences.
- Option D:** The methyl group exhibits an electron-donating inductive effect (+I), which slightly reduces acid strength rather than increasing it.

Question #122 Key: (B)CHEMISTRY
09. Thermochemistry

The conversion of a neutral gaseous sodium atom into a sodium cation is a(n):

CORE CONCEPT & DERIVATION

First ionization energy is the minimum energy required to overcome the attractive force of the nucleus and remove an electron from a gaseous atom.

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

- Work must be done against the electrostatic force binding the valence electron to the positively charged nucleus.
- Because energy is absorbed from the surroundings ($\Delta H > 0$), the ionization process is endothermic.

Why other options are incorrect:

- Option A:** Electron removal is never exothermic for neutral ground-state atoms.
- Option C:** Thermoneutral processes involve zero enthalpy change ($\Delta H = 0$).
- Option D:** Sublimation is the phase transition from solid directly to gas ($\text{Na}_{(s)} \rightarrow \text{Na}_{(g)}$), which does not involve ionization.

Question #123 Key: (A)PHYSICS
11. Electromagnetic Induction

The maximum (peak) induced electromotive force generated in an AC generator coil rotating in a ...

CORE CONCEPT & DERIVATION

Faraday's law shows that the peak induced electromotive force in a rotating generator depends solely on magnetic flux rate parameters, not on circuit resistance.

Formula / Rule / Reaction:

$$\varepsilon_0 = NBA\omega = 2\pi fNBA$$

Solution:

- Peak induced EMF (ε_0) depends directly on the number of turns (N), magnetic field strength (B), coil area (A), and angular frequency (ω).
- The electrical resistance (R) of the coil wire determines the induced current ($I_0 = \varepsilon_0 / R$), but has no effect on the magnitude of the generated EMF itself.
- Note on board key:** Some test keys erroneously marked Option C; standard electromagnetic theory confirms that peak EMF is independent of coil resistance (Option A).

Why other options are incorrect:

- Option B:** Peak EMF is directly proportional to the number of turns ($\varepsilon_0 \propto N$).
- Option C:** Peak EMF is directly proportional to coil cross-sectional area ($\varepsilon_0 \propto A$).
- Option D:** Peak EMF is directly proportional to rotational frequency ($\varepsilon_0 \propto f$).

Question #124 Key: (D)PHYSICS
09. Current Electricity

Which of the following electrical components is classified as an Ohmic device?

CORE CONCEPT & DERIVATION

An Ohmic device strictly obeys Ohm's law, showing a linear relationship between current and voltage at constant temperature.

Formula / Rule / Reaction:

$$V = IR; \quad R = \text{constant} \implies I-V \text{ plot is a straight line through the origin}$$

Solution:

- Metallic conductors, such as copper wire, possess a constant resistance across a wide range of applied voltages at steady temperature.
- Consequently, copper wire behaves as an Ohmic conductor.

Why other options are incorrect:

- Option A:** As current heats a tungsten filament, its resistance rises non-linearly, giving a curved I-V characteristic.
- Option B:** Transistors are active semiconductor devices with non-linear transfer curves.
- Option C:** A diode conducts current asymmetrically in an exponential, non-Ohmic manner.

Question #125 Key: (B)PHYSICS
11. Electromagnetic Induction

According to Faraday's law of induction, an electromotive force is induced in a conducting circ...

CORE CONCEPT & DERIVATION

Faraday's law dictates that an electromotive force is induced in a closed loop only when the magnetic flux threading the loop changes with time.

Formula / Rule / Reaction:

$$\varepsilon = -N \frac{\Delta \Phi_B}{\Delta t}$$

Solution:

- A non-zero rate of change of magnetic flux ($\Delta \Phi_B / \Delta t \neq 0$) induces an electric field along the conductor.
- If the magnetic flux remains constant, no EMF is induced.

Why other options are incorrect:

- **Option A:** A changing electric flux produces an induced magnetic field (Maxwell's displacement current), not an induced EMF in a wire loop.
- **Option C:** Without magnetic flux, electromagnetic induction cannot take place.
- **Option D:** A stationary magnetic field produces constant flux ($\Delta \Phi_B = 0$), yielding zero induced EMF.

Question #126 Key: (C)PHYSICS
13. Electronics

A circuit that smooths the pulsating direct current output of a rectifier into a steady direct ...

CORE CONCEPT & DERIVATION

A filter circuit suppresses AC ripple components from rectified DC output while allowing the steady DC level to reach the load.

Formula / Rule / Reaction:

$$\text{Pulsating DC} \xrightarrow{\text{Filter (Capacitor/Choke)}} \text{Smooth Steady DC}$$

Solution:

- Rectifiers produce unidirectional current with significant alternating ripple voltage.
- Filter networks (such as shunt capacitors or pi-filters) store charge during peaks and discharge during troughs, smoothing the waveform into steady DC.

Why other options are incorrect:

- **Option A:** An electrical generator converts mechanical energy into alternating or direct electrical current.
- **Option B:** A transformer changes AC voltage levels via mutual inductance, but cannot operate on direct current.
- **Option D:** While an inductive choke can serve as an element inside a filter, the complete circuit that smooths voltage is designated as a filter circuit.

Question #127 Key: (C)PHYSICS
04. Rotational & Circular Motion

According to the right-hand rule for rotational kinematics, the vector direction of angular dis...

CORE CONCEPT & DERIVATION

Angular displacement is an axial vector directed along the axis of rotation as determined by the right-hand grip rule.

Formula / Rule / Reaction:

$$\vec{\Delta \theta} \parallel \text{Axis of rotation (Right-hand thumb rule)}$$

Solution:

- To determine the vector direction of angular displacement, curl the fingers of the right hand in the direction of rotational motion.
- The extended thumb points along the axis of rotation, defining the vector direction of $\Delta \theta$.
- **Note on board key:** Some transcripts marked 'curl of fingers'; the curled fingers define the sense of rotation, while the axial vector itself points along the thumb (Option C).

Why other options are incorrect:

- **Option A:** The curled fingers indicate the curved path of rotational motion, not the axial vector direction.
- **Option B:** The index finger is used in Fleming's rules for magnetic forces, not for angular vectors.
- **Option D:** Linear velocity is tangential to the circular path, perpendicular to the axial angular displacement vector.

Question #128 Key: (D)PHYSICS
02. Force & Motion

During the flight of a projectile, atmospheric air friction directly affects:

CORE CONCEPT & DERIVATION

Aerodynamic drag opposes the instantaneous velocity vector of a projectile, resolving into retarding forces along both axes.

Formula / Rule / Reaction:

$$\vec{F}_d = -\frac{1}{2} C_d \rho A v \vec{v} \implies F_{dx} = -k v v_x, \quad F_{dy} = -k v v_y$$

Solution:

- Because air resistance acts in the direction opposite to instantaneous velocity, it decomposes into retarding forces along both horizontal and vertical directions.
- Consequently, both horizontal velocity and vertical trajectory are altered by air resistance.

Why other options are incorrect:

- **Option A:** The launch angle is an initial parameter determined before the projectile encounters atmospheric flight drag.
- **Option B:** Drag slows vertical motion as well as horizontal motion.
- **Option C:** Drag retards horizontal motion throughout flight, reducing the range.

Question #129 Key: (C)PHYSICS
05. Waves

A periodic wave is fundamentally characterized by which set of three interrelated physical parameters...

CORE CONCEPT & DERIVATION

The propagation of any wave is governed by the universal wave equation connecting spatial wavelength, temporal frequency, and propagation velocity.

Formula / Rule / Reaction:

$$v = f\lambda$$

Solution:

- Wavelength (λ) represents the spatial cycle distance.
- Frequency (f) represents the temporal rate of oscillation.
- Speed (v) represents the propagation rate through the medium.
- These three parameters define periodic wave transmission via the wave equation.

Why other options are incorrect:

- **Option A:** Acceleration describes individual particle dynamics in the medium rather than the wave's general propagation parameters.
- **Option B:** Acceleration is not one of the three primary kinematic wave parameters.
- **Option D:** Instantaneous displacement varies continuously across space and time rather than serving as a fundamental wave parameter.

Question #130 Key: (D)PHYSICS
14. Dawn of Modern Physics

Which of the following physical experiments provides direct experimental proof of the particle nature of light...

CORE CONCEPT & DERIVATION

The photoelectric effect demonstrates that electromagnetic radiation transfers energy in localized, quantized packets (photons).

Formula / Rule / Reaction:

$$E = h\nu = \Phi + K_{\max}$$

Solution:

- Classical wave theory fails to explain why electron emission occurs instantaneously above a threshold frequency regardless of intensity.
- Albert Einstein explained the effect by proposing that light behaves as discrete particle-like packets of energy (photons), proving the corpuscular nature of radiation.

Why other options are incorrect:

- **Option A:** Optical interference is direct proof of the wave nature of light.
- **Option B:** Diffraction (the bending of light around obstacles) is a wave phenomenon.
- **Option C:** Reflection is readily explained using Huygens' principle and wave theory.

Question #131 Key: (B)PHYSICS
13. Electronics

To achieve superior resolving power and sharp spectral line separation, modern spectrometers utilize...

CORE CONCEPT & DERIVATION

A diffraction grating features thousands of closely spaced parallel slits per centimeter, producing sharp interference maxima.

Formula / Rule / Reaction:

$$d \sin \theta = m\lambda; \quad R = \frac{\lambda}{\Delta\lambda} = Nm$$

Solution:

- A diffraction grating has a high line density (e.g., 600 lines/mm).
- Multiple-beam interference produces sharp, bright spectral lines, giving modern spectrometers higher resolving power than simple prisms.

Why other options are incorrect:

- **Option A:** Capacitors store electrical potential energy and cannot disperse optical spectra.
- **Option C:** A mica window serves as a thin radiation entrance partition in Geiger-Muller tubes.
- **Option D:** Polarizers filter electromagnetic wave vector orientations without dispersing wavelengths.

Question #132 Key: (C)PHYSICS
11. Electromagnetic Induction

A permanent bar magnet falls vertically under gravity along the axis of a long, vertical hollow...

CORE CONCEPT & DERIVATION

A moving magnetic field induces circulating eddy currents in nearby conductors; by Lenz's law, these currents create an opposing magnetic force.

Formula / Rule / Reaction:

$$ma = mg - F_{\text{magnetic}} \implies a = g - \frac{F_m}{m} < g$$

Solution:

- As the bar magnet falls through the copper tube, its changing magnetic flux induces circumferential eddy currents in the copper wall.
- According to Lenz's law, these induced currents generate an upward magnetic force that opposes the magnet's motion.
- This retarding force reduces the downward acceleration to a value less than the acceleration due to gravity ($a < g$).

Why other options are incorrect:

- Option A:** Acceleration would equal g only in an electrical insulator where eddy currents cannot flow.
- Option B:** An acceleration greater than g would violate Lenz's law and the conservation of energy.
- Option D:** Acceleration is not zero initially; it decreases until terminal velocity is reached.

Question #133 Key: (A)PHYSICS
13. Electronics

An electric lamp has a power rating of 20 W and operates at an efficiency of 50%. What is its u...

CORE CONCEPT & DERIVATION

Energy efficiency is defined as the ratio of useful output power to total input power expressed as a percentage.

Formula / Rule / Reaction:

$$\text{Efficiency}(\eta) = \frac{P_{\text{out}}}{P_{\text{in}}} \times 100\% \implies P_{\text{out}} = P_{\text{in}} \times \frac{\eta}{100\%}$$

Solution:

- Input power $P_{\text{in}} = 20 \text{ W}$.
- Efficiency $\eta = 50\% = 0.50$.
- Useful output power:

$$P_{\text{out}} = 20 \text{ W} \times 0.50 = 10 \text{ W}$$

- Note on board key:** Some answer keys contained a typographical error listing 12 W; the correct mathematical value is 10 W.

Why other options are incorrect:

- Option B:** 15 W corresponds to an efficiency of 75%.
- Option C:** 18 W corresponds to an efficiency of 90%.
- Option D:** 20 W would represent an ideal, 100% efficient device without energy losses.

Question #134 Key: (A)PHYSICS
05. Waves

Mechanical longitudinal waves (sound waves) propagate fastest through which state of matter?

CORE CONCEPT & DERIVATION

The velocity of longitudinal waves depends on the ratio of the medium's elastic modulus to its inertial density.

Formula / Rule / Reaction:

$$v = \sqrt{\frac{E}{\rho}}; \quad E_{\text{solid}} \gg E_{\text{liquid}} \gg E_{\text{gas}}$$

Solution:

- Although solids are denser than liquids and gases, their elastic bulk and Young's moduli are several orders of magnitude higher due to strong interatomic bonds.
- This high elastic stiffness allows longitudinal stress waves to propagate fastest through solids.

Why other options are incorrect:

- Option B:** Liquids have much lower bulk moduli than solids, resulting in slower wave propagation.
- Option C:** Gases are highly compressible with very low elastic moduli, giving the lowest sound speeds.
- Option D:** Plasma behaves as a compressible, high-temperature ionized gas with sound speeds generally lower than dense solids.

Question #135 Key: (D)PHYSICS
08. Electrostatics

The electrostatic potential at the geometric center of an isolated, uniformly charged conducting...

CORE CONCEPT & DERIVATION

Electrostatic equilibrium requires the interior of a static conductor to be an equipotential region with zero internal electric field.

Formula / Rule / Reaction:

$$E = -\frac{dV}{dr} = 0 \implies V(r) = \text{constant} = V_{\text{surface}} = \frac{1}{4\pi\epsilon_0} \frac{q}{R}$$

Solution:

- By Gauss's law, excess static charge resides entirely on the outer surface of a conductor, making the internal electric field zero everywhere inside.
- Because no work is done moving a test charge within this zero-field region, the potential at the center is identical to the potential at the outer surface.

Why other options are incorrect:

- Option A:** The electric field is zero inside, but the electric potential is non-zero and constant.
- Option B:** A potential difference between center and surface would induce charge flow, violating electrostatic equilibrium.
- Option C:** The interior cannot be at a higher potential than the surface in a static conductor.

Question #136 Key: (C)PHYSICS
16. Nuclear Physics

In a radioactive decay experiment, the count rate of an isotope drops from 400 counts/second to...

CORE CONCEPT & DERIVATION

Radioactive decay follows first-order kinetics where the activity halves after each elapsed half-life.

Formula / Rule / Reaction:

$$N_t = N_0 \left(\frac{1}{2}\right)^n; \quad n = \frac{t}{T_{1/2}}$$

Solution:

- Determine the number of half-lives (n):

$$400 \xrightarrow{1} 200 \xrightarrow{2} 100 \xrightarrow{3} 50 \implies n = 3 \text{ half-lives}$$

- Calculate the half-life:

$$T_{1/2} = \frac{\text{Total time}}{n} = \frac{150 \text{ minutes}}{3} = 50 \text{ minutes}$$

Why other options are incorrect:

- Option A:** 30 minutes would mean 5 half-lives, reducing the count rate to 12.5 counts/second.
- Option B:** 40 minutes does not yield an integer number of half-lives for the observed eightfold reduction.
- Option D:** 60 minutes over 150 minutes corresponds to 2.5 half-lives, giving an activity of roughly 71 counts/second.

Question #137 Key: (C)PHYSICS
13. Electronics

Which of the following statements regarding magnetic attraction is true?

CORE CONCEPT & DERIVATION

Ferromagnetism occurs in materials containing permanent atomic magnetic dipoles that align within magnetic domains.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Permanent magnets attract ferromagnetic materials (such as iron, nickel, cobalt, and steel).
- External magnetic fields align the magnetic domains in these materials, producing strong attraction.

Why other options are incorrect:

- Option A:** Plastics are diamagnetic or non-magnetic polymers that do not exhibit magnetic attraction.
- Option B:** Many metals (such as copper, silver, and gold) are diamagnetic and are weakly repelled by magnetic fields.
- Option D:** Aluminum is paramagnetic and is not visibly attracted to standard permanent magnets.

Question #138 Key: (C)PHYSICS
05. Waves

The kinetic energy of a simple harmonic oscillator is twice its potential energy at a displacement...

CORE CONCEPT & DERIVATION

Total mechanical energy in simple harmonic motion is conserved, dividing between kinetic and elastic potential energy based on displacement.

Formula / Rule / Reaction:

$$KE = \frac{1}{2}k(x_0^2 - x^2); \quad PE = \frac{1}{2}kx^2; \quad \text{Condition: } KE = 2PE$$

Solution:

- Substitute the energy expressions into the condition:

$$\frac{1}{2}k(x_0^2 - x^2) = 2\left(\frac{1}{2}kx^2\right)$$

$$x_0^2 - x^2 = 2x^2 \implies x_0^2 = 3x^2 \implies x^2 = \frac{x_0^2}{3}$$

$$x = \frac{x_0}{\sqrt{3}}$$

Why other options are incorrect:

- Option A:** At $x = x_0/2$, $PE = \frac{1}{4}E_{\text{total}}$ and $KE = 3PE$.
- Option B:** At $x = x_0/\sqrt{2}$, kinetic and potential energies are equal ($KE = PE$).
- Option D:** At $x = 2x_0/3$, $PE = \frac{4}{9}E_{\text{total}}$ and $KE = \frac{5}{9}E_{\text{total}}$.

Question #139 Key: (C)PHYSICS
13. Electronics

When a positively charged body is brought near an isolated, uncharged conducting cylinder on an...

CORE CONCEPT & DERIVATION

Electrostatic induction causes mobile conduction electrons to redistribute within a conductor under the influence of an external electric field.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- A nearby positive charge attracts mobile free electrons toward the near face of the conductor, creating an accumulation of opposite (negative) charge.
- The far end loses electrons, leaving behind an equal excess of like (positive) charge.

Why other options are incorrect:

- Option A:** Like charges repel; the near end cannot acquire the same charge as the inducing body.
- Option B:** While the net charge of the isolated cylinder remains zero, charge separation is actively induced.
- Option D:** Conservation of electric charge prevents both ends from acquiring the same sign of charge.

Question #140 Key: (D)PHYSICS
09. Current Electricity

The fractional change in electrical resistance per kelvin change in temperature is defined as t...

CORE CONCEPT & DERIVATION

The temperature coefficient of resistance (α) quantifies how a conductor's resistance responds to changes in temperature.

Formula / Rule / Reaction:

$$\alpha = \frac{\Delta R}{R_0 \Delta T} = \frac{R_T - R_0}{R_0(T - T_0)}$$

Solution:

- The term $\Delta R/R_0$ represents the fractional change in resistance.
- Dividing by the temperature change (ΔT) gives the fractional change in resistance per kelvin, which defines the temperature coefficient of resistance (α).

Why other options are incorrect:

- Option A:** Conductivity (σ) is the inverse of resistivity, measured in siemens per meter (S/m).
- Option B:** Resistivity (ρ) is the intrinsic bulk resistance of a unit cube of material.
- Option C:** The temperature coefficient of resistivity is defined by fractional changes in resistivity ($\Delta\rho/\rho_0\Delta T$) rather than total circuit resistance.

Question #141 Key: (C)PHYSICS
03. Work & Energy

A person pushes with high muscular effort against a rigid brick wall but fails to move it. The ...

CORE CONCEPT & DERIVATION

Mechanical work is defined in physics as the scalar product of the applied force vector and the resulting displacement vector.

Formula / Rule / Reaction:

$$W = \vec{F} \cdot \vec{d} = Fd \cos \theta; \quad d = 0 \implies W = 0$$

Solution:

- Although the person applies a physical force, the wall experiences zero displacement ($d = 0$).
- From the definition of mechanical work, if displacement is zero, the work done on the wall is zero.

Why other options are incorrect:

- Option A:** Negative work requires a displacement directed opposite to the applied force vector.
- Option B:** Positive work requires a non-zero displacement in the direction of the applied force.
- Option D:** Maximum work requires maximum force along a substantial displacement parallel to the force.

Question #142 Key: (D)PHYSICS
04. Rotational & Circular Motion

What is the ratio of the angular speed of the minute hand to that of the hour hand of a standard...

CORE CONCEPT & DERIVATION

Angular speed is inversely proportional to the period required to complete one full revolution (2π radians).

Formula / Rule / Reaction:

$$\omega = \frac{2\pi}{T}; \quad \frac{\omega_{\text{minute}}}{\omega_{\text{hour}}} = \frac{T_{\text{hour}}}{T_{\text{minute}}}$$

Solution:

- The minute hand completes one revolution in 1 hour ($T_{\text{minute}} = 1 \text{ h}$).
- The hour hand completes one revolution in 12 hours ($T_{\text{hour}} = 12 \text{ h}$).
- Calculate the ratio of their angular speeds:

$$\frac{\omega_{\text{minute}}}{\omega_{\text{hour}}} = \frac{12 \text{ h}}{1 \text{ h}} = 12 : 1$$

Why other options are incorrect:

- Option A:** 1 : 8 is an incorrect ratio.
- Option B:** 6 : 1 incorrectly assumes the hour hand completes a revolution in 6 hours.
- Option C:** 1 : 12 inverts the ratio, representing the speed of the hour hand relative to the minute hand.

Question #143 Key: (C)PHYSICS
02. Force & Motion

Which of the following vector pairs always points in the exact same direction during linear mot...

CORE CONCEPT & DERIVATION

Newton's second law of motion dictates that acceleration is directly proportional to and in the same direction as the net force vector.

Formula / Rule / Reaction:

$$\vec{F}_{\text{net}} = m\vec{a}; \quad m > 0 \implies \hat{F} = \hat{a}$$

Solution:

- Because mass (m) is a positive scalar quantity, multiplying the acceleration vector by mass does not alter its direction.
- Therefore, the net force vector and the resulting acceleration vector always point in the exact same direction.

Why other options are incorrect:

- Option A:** Net force and displacement point in opposite directions when a braking force slows a forward-moving body.
- Option B:** When an object slows down, the net force opposes the velocity vector.
- Option D:** Velocity and acceleration are antiparallel during deceleration.

Question #144 Key: (D)PHYSICS
02. Force & Motion

Newton's third law of motion establishes which fundamental principle regarding forces in nature...

CORE CONCEPT & DERIVATION

Forces are mutual interactions between two bodies, meaning an isolated single force cannot exist in nature.

Formula / Rule / Reaction:

$$\vec{F}_{AB} = -\vec{F}_{BA}$$

Solution:

- Newton's third law states that whenever body A exerts a force on body B, body B exerts an equal and opposite force on body A.
- Forces always exist in interacting action-reaction pairs acting on different bodies.

Why other options are incorrect:

- Option A:** The quantitative relationship between force and acceleration is governed by Newton's second law.
- Option B:** Single, isolated forces cannot exist in nature.
- Option C:** Resultant net forces are calculated using vector superposition, not Newton's third law.

Question #145 Key: (C)PHYSICS
07. Thermodynamics

Thermal equilibrium between bodies in an environment is established through the process of:

CORE CONCEPT & DERIVATION

Thermal equilibrium is achieved when heat flows spontaneously from a region of higher temperature to one of lower temperature until temperatures equalize.

Formula / Rule / Reaction:

$$Q = mc\Delta T; \quad T_1 = T_2 \implies \frac{dQ}{dt} = 0$$

Solution:

- According to the zeroth law of thermodynamics, bodies in thermal contact exchange energy via heat flow driven by a temperature difference.
- Net heat exchange ceases once both bodies reach identical temperatures, establishing thermal equilibrium.

Why other options are incorrect:

- Option A:** Continuous heat generation creates persistent temperature gradients, preventing equilibrium.
- Option B:** Radiative dissipation into space cools a body rather than equilibrating it with its surroundings.
- Option D:** Thermal equilibrium requires dynamic heat transfer between objects until equilibrium is reached.

Question #146 Key: (A)PHYSICS
05. Waves

A second's pendulum begins oscillating from its extreme position. What is the ratio of its ampl...

CORE CONCEPT & DERIVATION

A second's pendulum has a defined time period of $T = 2$ s, meaning each half-swing takes exactly 1 second.

Formula / Rule / Reaction:

$$T = 2 \text{ s}; \quad x(t) = x_0 \cos(\omega t) = x_0 \cos\left(\frac{2\pi}{T}t\right)$$

Solution:

- The pendulum starts at an extreme position ($x(0) = x_0$).
- In 7 seconds, the number of complete half-swings is 7.
- After an odd number of seconds (1, 3, 5, 7 s), the bob reaches the opposite extreme position, where displacement magnitude is $|x| = x_0$.
- Physically, the ratio of amplitude to displacement magnitude is $x_0/x_0 = 1 : 1$.
- *Note on board key:* The official examination key designated Option A (1 : 2) based on an erroneous answer key convention. Option C corresponds to the ratio 1:14.

Why other options are incorrect:

- **Option B:** 1 : 4 is an incorrect distractor.
- **Option C:** 1 : 14 represents a corrupted option (healed from '01:14:00').
- **Option D:** An infinite ratio would occur only at the equilibrium position ($x = 0$), which is not where the bob is at 7 seconds.

Question #147 Key: (C)PHYSICS
14. Dawn of Modern Physics

When a positron and an electron collide at low energy, they annihilate to produce:

CORE CONCEPT & DERIVATION

Matter-antimatter annihilation converts the rest masses of the colliding particles into electromagnetic energy while conserving linear momentum.

Formula / Rule / Reaction:

$$e^- + e^+ \rightarrow 2\gamma; \quad E_\gamma = m_0c^2 = 0.511 \text{ MeV}$$

Solution:

- In the center-of-mass frame, the total initial momentum of the electron-positron pair is zero.
- To conserve both energy and momentum, annihilation produces at least two gamma-ray photons emitted in opposite directions (back-to-back, 180° apart), each carrying 0.511 MeV of energy.

Why other options are incorrect:

- **Option A:** Alpha particles are helium nuclei (${}^4_2\text{He}$), not the products of lepton annihilation.
- **Option B:** A single photon cannot be produced because it cannot conserve both energy and linear momentum simultaneously.
- **Option D:** X-rays arise from atomic electron transitions or bremsstrahlung, not from electron-positron mass-energy annihilation.

Question #148 Key: (C)PHYSICS
03. Work & Energy

An electric motor does 140,000 J of work in lifting an elevator over a duration of 70 seconds...

CORE CONCEPT & DERIVATION

Power is the rate at which work is performed or energy is transferred over time.

Formula / Rule / Reaction:

$$P = \frac{W}{t}$$

Solution:

- Work done $W = 140,000$ J.
- Time taken $t = 70$ s.
- Calculate the power output:

$$P = \frac{140,000 \text{ J}}{70 \text{ s}} = 2000 \text{ W} = 2.0 \text{ kW}$$

Why other options are incorrect:

- **Option A:** 0.50 mW results from dividing time by work and misapplying metric prefixes.
- **Option B:** 2.0 W is too small by a factor of 10^3 (watts instead of kilowatts).
- **Option D:** 9.8 MW results from erroneously multiplying the work by gravitational acceleration.

Question #149 Key: (A)PHYSICS
13. Electronics

The internal resistance of a chemical galvanic cell or battery arises primarily from the:

CORE CONCEPT & DERIVATION

A real battery experiences an internal voltage drop due to the finite electrical resistance of its chemical electrolyte and internal separators.

Formula / Rule / Reaction:

$$V = \mathcal{E} - Ir; \quad r = \text{internal resistance of electrolyte and electrodes}$$

Solution:

- As current flows internally between the electrodes, ions migrate through the electrolyte and porous separators.
- Finite ion mobility, viscosity of the liquid medium, and electrode contact interfaces generate internal resistance (r).

Why other options are incorrect:

- **Option B:** Ion motion constitutes the electric current itself rather than the resistance encountered.
- **Option C:** Static charges on the non-conducting exterior casing do not affect the internal electrochemical circuit.
- **Option D:** External terminals contribute to external circuit resistance, not the battery's internal resistance.

Question #150 Key: (A)PHYSICS
10. Electromagnetism

A magnetic field is generated in space exclusively by:

CORE CONCEPT & DERIVATION

Stationary charges produce only electrostatic fields, whereas moving electric charges (currents) generate magnetic fields.

Formula / Rule / Reaction:

$$\vec{B} = \frac{\mu_0}{4\pi} \frac{q(\vec{v} \times \vec{r})}{r^2} \quad (\text{Biot-Savart Law for a moving point charge})$$

Solution:

- A stationary charge ($v = 0$) generates only a radial electrostatic field (E).
- When an electric charge moves with velocity $\vec{v}$, it produces an accompanying magnetic field ($\vec{B}$) around its path.

Why other options are incorrect:

- **Option B:** Stationary charges produce only electric fields.
- **Option C:** Stationary charges do not generate magnetic fields.
- **Option D:** Neutral mass distributions produce gravitational fields rather than magnetic fields.

Question #151 Key: (A)PHYSICS
07. Thermodynamics

When additional air is pumped into a bicycle tire at constant temperature, the internal pressure...

CORE CONCEPT & DERIVATION

According to kinetic molecular theory, gas pressure is the average force exerted per unit area by gas molecules colliding elastically with the container walls.

Formula / Rule / Reaction:

$$P = \frac{1}{3} \rho \overline{v^2} = \frac{1}{3} \left(\frac{Nm}{V} \right) \overline{v^2}$$

Solution:

- Pumping more air into a tire of approximately fixed volume increases the number of molecules (N) per unit volume.
- Because temperature (and thus root-mean-square velocity $\overline{v^2}$) is constant, the rate of molecular collisions per second against the inner walls increases, raising pressure.

Why other options are incorrect:

- **Option B:** Gas molecules have fixed sub-nanometer dimensions and do not expand in size when pumped.
- **Option C:** Adding molecules into a fixed volume reduces the mean intermolecular distance rather than increasing it.
- **Option D:** Intermolecular attractive forces are negligible in gases under near-ideal conditions and tend to reduce pressure rather than increase it.

Question #152 Key: (C)PHYSICS
05. Waves

The spatial distance traveled by a periodic wave during one complete temporal period is defined...

CORE CONCEPT & DERIVATION

Wavelength is the linear distance between two successive wave points in identical phase, which equals the distance covered in one oscillation period.

Formula / Rule / Reaction:

$$\lambda = vT = \frac{v}{f}$$

Solution:

- During one period (T), a wave completes one full cycle of oscillation.
- The physical distance the wave front propagates through the medium during this interval is, by definition, its wavelength (λ).

Why other options are incorrect:

- Option A:** Frequency is the temporal rate of complete oscillations executed per unit time (measured in hertz).
- Option B:** Time period is the duration in seconds required to complete one full cycle.
- Option D:** Wavenumber is the spatial frequency, defined as the number of waves per unit length ($\bar{\nu} = 1/\lambda$).

Question #153 Key: (A)PHYSICS
16. Nuclear Physics

Radioactive isotopes can be artificially synthesized by bombarding stable target nuclei with:

CORE CONCEPT & DERIVATION

Artificially induced radioactivity is initiated when an uncharged projectile penetrates a stable nucleus without experiencing Coulomb repulsion.

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

- Because neutrons carry zero electric charge, they are not repelled by the positively charged atomic nucleus.
- Neutrons can easily penetrate and be captured by stable nuclei inside a nuclear reactor, producing unstable radionuclides (such as Cobalt-60 from Cobalt-59).

Why other options are incorrect:

- Option B:** Visible light photons lack sufficient energy (a few eV) to induce nuclear transmutations.
- Option C:** Low-energy electrons interact exclusively with the atomic electron cloud, causing atomic excitation or ionization rather than nuclear transformation.
- Option D:** Positrons annihilate with atomic electrons upon contact, releasing gamma rays rather than integrating into target nuclei.

Question #154 Key: (B)PHYSICS
02. Force & Motion

A stone is released from rest from the top of a building 80 m above the ground. Neglecting air ...

CORE CONCEPT & DERIVATION

For an object dropped from rest under uniform gravitational acceleration, the elapsed descent time is governed by kinematics.

Formula / Rule / Reaction:

$$h = v_i t + \frac{1}{2} g t^2; \quad v_i = 0 \implies t = \sqrt{\frac{2h}{g}}$$

Solution:

- Initial velocity $v_i = 0$ m/s, height $h = 80$ m, and $g = 10$ m/s².
- Substitute values into the kinematic relation:

$$t = \sqrt{\frac{2 \times 80}{10}} = \sqrt{\frac{160}{10}} = \sqrt{16} = 4 \text{ s}$$

Why other options are incorrect:

- Option A:** In 2 s, the stone falls only $h = \frac{1}{2}(10)(2)^2 = 20$ m.
- Option C:** 8 s would correspond to a fall height of $h = \frac{1}{2}(10)(8)^2 = 320$ m. (Note: Early printings contained an OCR typographical error of '88' for this option).
- Option D:** In 10 s, the stone would fall 500 m.

Question #155 Key: (B)PHYSICS
10. Electromagnetism

The magnetic flux through a planar conducting loop is zero when the angle between the magnetic ...

CORE CONCEPT & DERIVATION

Magnetic flux is defined as the scalar dot product of the uniform magnetic field vector and the surface vector area.

Formula / Rule / Reaction:

$$\Phi_B = \vec{B} \cdot \vec{A} = BA \cos \theta; \quad \theta = 90^\circ \implies \Phi_B = 0$$

Solution:

- The vector area ($\vec{A}$) points perpendicular to the surface of the loop.
- When the angle θ between $\vec{B}$ and $\vec{A}$ is 90° (meaning the magnetic field lies parallel to the surface of the coil), $\cos(90^\circ) = 0$, and the magnetic flux is zero.

Why other options are incorrect:

- Option A:** At $\theta = 0^\circ$, $\cos(0^\circ) = 1$, yielding the maximum possible flux ($\Phi_{\max} = BA$).
- Option C:** At $\theta = 60^\circ$, $\cos(60^\circ) = 0.5$, so the flux is half of its maximum value.
- Option D:** At $\theta = 30^\circ$, $\cos(30^\circ) = \sqrt{3}/2 \approx 0.866$, yielding non-zero flux.

Question #156 Key: (B)PHYSICS
13. Electronics

Dental restorative materials used for fillings in teeth should ideally be fabricated from a sub...

CORE CONCEPT & DERIVATION

Thermal expansion matching between biological tooth tissue and restorative materials prevents mechanical strain, microleakage, and marginal failure.

Formula / Rule / Reaction:

$$\alpha_{\text{filling}} \approx \alpha_{\text{tooth}}; \quad \Delta L = \alpha L_0 \Delta T$$

Solution:

- Natural teeth experience temperature fluctuations from hot and cold food.
- If the filling has the same linear thermal expansion coefficient (α) as the tooth, both materials expand and contract at identical rates, preventing gaps, tooth fractures, or restoration loosening.

Why other options are incorrect:

- Option A:** A material with zero thermal expansion would pull away from an expanding tooth when heated, forming marginal gaps that admit bacteria.
- Option C:** Expanding less creates tensile stress and marginal leakage along the interface during warm meals.
- Option D:** Expanding more exerts outward hydrostatic pressure on adjacent tooth walls, risking enamel fracturing.

Question #157 Key: (A)PHYSICS
16. Nuclear Physics

When an unstable radioactive parent nucleus emits a pure gamma-ray photon, the mass number (A)...

CORE CONCEPT & DERIVATION

Gamma radiation consists of high-energy electromagnetic photons emitted during nuclear de-excitation without changing nucleon count.

Formula / Rule / Reaction:

$${}^A_Z X^* \rightarrow {}^A_Z X + \gamma; \quad \Delta A = 0, \Delta Z = 0$$

Solution:

- A gamma photon carries electromagnetic energy but zero rest mass and zero electrical charge.
- When an excited isomer de-excites by gamma emission, neither the proton count (Z) nor the neutron count changes; therefore, the mass number (A) remains unchanged.

Why other options are incorrect:

- Option B:** An increase in mass number does not occur in natural radioactive decay.
- Option C:** A decrease of 1 unit in mass number occurs during neutron emission, not gamma decay.
- Option D:** An increase of 1 in mass number requires capture of an external nucleon.

Question #158 Key: (B)PHYSICS
10. Electromagnetism

In the International System of Units (SI), centripetal force is measured in:

CORE CONCEPT & DERIVATION

Centripetal force is a dynamic force directed toward the center of curvature that maintains circular motion.

Formula / Rule / Reaction:

$$F_c = \frac{mv^2}{r}; \quad [F_c] = \text{kg} \cdot \text{m} \cdot \text{s}^{-2} = \text{Newton (N)}$$

Solution:

- Like all mechanical forces in classical physics, centripetal force represents mass times acceleration.
- Its derived SI unit is the newton (N).

Why other options are incorrect:

- Option A:** The joule (J) is the SI unit of work and energy.
- Option C:** The tesla (T) is the SI unit of magnetic flux density.
- Option D:** The watt (W) is the SI unit of power.

Question #159 Key: (B)PHYSICS
08. Electrostatics

A charged particle moves through a uniform electric field established between two oppositely ch...

CORE CONCEPT & DERIVATION

The electrostatic Coulomb force exerted on a charge by an electric field depends solely on field strength and charge magnitude, independent of velocity.

Formula / Rule / Reaction:

$$F_e = qE = q\left(\frac{V}{d}\right)$$

Solution:

- The electric force depends on the particle charge (q), the potential difference (V), and the plate separation (d).
- Unlike magnetic Lorentz forces ($F_B = qvB$), the electrostatic force is completely independent of the particle's speed (v).

Why other options are incorrect:

- Option A:** Charge (q) is directly proportional to force ($F_e \propto q$) and is required.
- Option C:** Plate separation (d) determines the electric field gradient ($E = V/d$) and is required.
- Option D:** Potential difference (V) determines field magnitude and is required.

Question #160 Key: (C)

PHYSICS
04. Rotational & Circular Motion

Which of the following physical systems provides the best real-world approximation of uniform c...

CORE CONCEPT & DERIVATION

Uniform circular motion requires a particle to travel along a circular path at a constant tangential speed with constant angular velocity.

Formula / Rule / Reaction:

$$r = \text{constant}, \quad \omega = \text{constant} \implies v = r\omega = \text{constant}$$

Solution:

- The tip of a clock's minute hand sweeps out a fixed planar circular radius at a constant angular speed of $2\pi \text{ rad}/3600 \text{ s}$.
- Because its tangential speed remains constant without angular acceleration, it represents uniform circular motion.

Why other options are incorrect:

- Option A:** Earth's orbit is elliptical according to Kepler's first law, and its orbital speed varies from perihelion to aphelion.
- Option B:** A vertical circular path involves gravity accelerating the mass downward and decelerating it upward, making speed non-uniform.
- Option D:** A spinning top undergoes gyroscopic precession and frictional deceleration.

Question #161 Key: (D)

PHYSICS
02. Force & Motion

A body of mass 5 kg moves with an initial linear momentum of 10 kg m/s . A constant force of 0.2 N ...

CORE CONCEPT & DERIVATION

The impulse delivered to a body equals its change in linear momentum, from which the change in kinetic energy is calculated.

Formula / Rule / Reaction:

$$J = F\Delta t = \Delta p = p_f - p_i; \quad K = \frac{p^2}{2m} \implies \Delta K = \frac{p_f^2 - p_i^2}{2m}$$

Solution:

- Initial momentum $p_i = 10 \text{ kg} \cdot \text{m/s}$.
- Impulse applied: $J = F\Delta t = (0.2 \text{ N})(10 \text{ s}) = 2 \text{ kg} \cdot \text{m/s}$.
- Final momentum: $p_f = p_i + J = 10 + 2 = 12 \text{ kg} \cdot \text{m/s}$.
- Increase in kinetic energy:

$$\Delta K = \frac{12^2 - 10^2}{2 \times 5} = \frac{144 - 100}{10} = \frac{44}{10} = 4.4 \text{ J}$$

Why other options are incorrect:

- Option A:** 2.8 J is an incorrect calculation.
- Option B:** 3.2 J results from improperly averaging the momenta.
- Option C:** 3.8 J is an arithmetic error.

Question #162 Key: (B)PHYSICS
02. Force & Motion

If two bodies of identical mass move with identical speeds, we can definitively conclude that:

CORE CONCEPT & DERIVATION

Linear momentum is a directional vector quantity, whereas kinetic energy is a non-directional scalar quantity.

Formula / Rule / Reaction:

$$\vec{p} = m\vec{v}; \quad K = \frac{1}{2}mv^2$$

Solution:

- Because mass and speed (scalar magnitude $|\vec{v}|$) are equal, both bodies have identical scalar kinetic energies.
- However, linear momentum depends on the directional vector $\vec{v}$. If the two bodies travel in different directions, their momentum vectors are distinct.

Why other options are incorrect:

- **Option A:** Momenta are identical only if both the magnitude and the direction of motion are the same.
- **Option C:** Kinetic energy depends only on mass and speed; because both are identical, their kinetic energies must be equal.
- **Option D:** Total energy depends on external potentials and is non-zero for moving masses.

Question #163 Key: (B)PHYSICS
08. Electrostatics

The electric field intensity at a distance of 4 meters from an isolated point charge is 200 N/C...

CORE CONCEPT & DERIVATION

According to Coulomb's law, the electrostatic field strength produced by a point charge follows an inverse-square relationship with distance.

Formula / Rule / Reaction:

$$E = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \Rightarrow E \propto \frac{1}{r^2}; \quad \frac{E_2}{E_1} = \left(\frac{r_1}{r_2}\right)^2$$

Solution:

- Initial distance $r_1 = 4$ m, initial field $E_1 = 200$ N/C.
- New distance $r_2 = 2$ m (distance is halved).
- Calculate new field intensity:

$$E_2 = E_1 \left(\frac{4}{2}\right)^2 = 200 \times (2)^2 = 200 \times 4 = 800 \text{ N/C}$$

Why other options are incorrect:

- **Option A:** 400 N/C incorrectly assumes an inverse linear relationship ($E \propto 1/r$).
- **Option C:** 600 N/C is a linear extrapolation.
- **Option D:** 1200 N/C is an incorrect scaling.

Question #164 Key: (A)PHYSICS
14. Dawn of Modern Physics

In the Compton scattering shift equation [Formula], the physical units of the quantity [Formul...

CORE CONCEPT & DERIVATION

Compton scattering describes the increase in photon wavelength following an inelastic collision with a stationary electron.

Formula / Rule / Reaction:

$$\Delta\lambda = \lambda' - \lambda; \quad [\Delta\lambda] = \text{meters (SI unit of length)}$$

Solution:

- $\Delta\lambda$ represents the difference between the scattered and incident photon wavelengths.
- Because wavelength is a spatial distance between successive wave crests, its dimensions are length (L), measured in meters or angstroms.

Why other options are incorrect:

- **Option B:** Time has base SI units of seconds (s).
- **Option C:** Mass has base SI units of kilograms (kg).
- **Option D:** Frequency has SI units of inverse seconds or hertz (s^{-1}).

Question #165 Key: (B)PHYSICS
08. Electrostatics

An electrostatic capacitor stores energy within its plates in the form of:

CORE CONCEPT & DERIVATION

Work performed in separating positive and negative charges onto opposing plates is stored as electrostatic potential energy in the dielectric field.

Formula / Rule / Reaction:

$$U = \frac{1}{2}CV^2 = \frac{1}{2} \frac{Q^2}{C} = \frac{1}{2}\epsilon_0 E^2 (\text{Volume})$$

Solution:

- Charging a capacitor involves transferring electrons against an accumulating electric potential difference.
- This input work is stored as electric potential energy localized within the electric field (E) between the conducting plates.

Why other options are incorrect:

- **Option A:** Kinetic energy is associated with charges in active hydrodynamic motion, not static stored charges.
- **Option C:** Thermal energy represents dissipated Joule heat loss during charging.
- **Option D:** Photonic light energy is emitted only if dielectric breakdown produces a spark.

Question #166 Key: (B)PHYSICS
08. Electrostatics

When the separation distance between two point charges is halved, the electrostatic Coulomb force...

CORE CONCEPT & DERIVATION

Coulomb's law dictates that electrostatic interaction force is inversely proportional to the square of the distance between point charges.

Formula / Rule / Reaction:

$$F = k \frac{|q_1 q_2|}{r^2}; \quad r' = \frac{r}{2} \Rightarrow F' = \frac{k|q_1 q_2|}{(r/2)^2} = 4F$$

Solution:

- Reducing the distance by a factor of 2 squares in the denominator: $(1/2)^2 = 1/4$.
- Inverting yields an electrostatic force that is four times ($4 \times$) its initial magnitude.

Why other options are incorrect:

- Option A:** One-fourth force occurs when the separation distance is doubled ($2r$).
- Option C:** Double force assumes an incorrect inverse linear relationship.
- Option D:** One-half force occurs if the distance were multiplied by $\sqrt{2}$.

Question #167 Key: (A)PHYSICS
02. Force & Motion

When an object moves along a straight line in a constant direction without reversing, its displ...

CORE CONCEPT & DERIVATION

Displacement is the shortest straight-line vector from initial to final position, while distance is the scalar path length traveled.

Formula / Rule / Reaction:

Unidirectional rectilinear motion: $|\vec{d}| = s$ (Displacement magnitude = Distance)

Solution:

- When motion occurs strictly along a straight path without directional reversal, the actual trajectory length exactly equals the straight-line displacement.
- Under this condition, scalar distance and vector displacement magnitude coincide.

Why other options are incorrect:

- Option B:** Force is an external dynamic push/pull measured in newtons.
- Option C:** Acceleration is the time rate of change of velocity.
- Option D:** Inertia is a measure of mass resisting changes in motion.

Question #168 Key: (C)PHYSICS
05. Waves

The speed of sound is noticeably faster in moist air than in dry air under identical temperatur...

CORE CONCEPT & DERIVATION

The speed of sound in a gas is inversely proportional to the square root of its density.

Formula / Rule / Reaction:

$$v = \sqrt{\frac{\gamma P}{\rho}}; \quad M(\text{H}_2\text{O}) = 18 \text{ g/mol} < M(\text{air}) \approx 29 \text{ g/mol} \Rightarrow \rho_{\text{moist}} < \rho_{\text{dry}}$$

Solution:

- Water vapor ($M = 18 \text{ g/mol}$) is lighter than diatomic nitrogen ($M = 28$) and oxygen ($M = 32$).
- Introducing moisture displaces heavier gases, reducing total air density (ρ) at constant pressure.
- Because sound speed is inversely proportional to $\sqrt{\rho}$, sound travels faster in less dense moist air.

Why other options are incorrect:

- Option A:** Moist air is lighter (less dense), not heavier, than dry air.
- Option B:** The adiabatic index (γ) for triatomic water vapor (≈ 1.33) is slightly lower than that for diatomic dry air (≈ 1.40).
- Option D:** Molecular acoustic absorption does not alter phase propagation speed.

Question #169 Key: (B)PHYSICS
11. Electromagnetic Induction

The electromotive force produced by an AC generator attains its maximum (peak) value when the p...

CORE CONCEPT & DERIVATION

Induced EMF depends on the time rate of change of magnetic flux, which reaches its maximum when the magnetic flux itself passes through zero.

Formula / Rule / Reaction:

$$\varepsilon(t) = \varepsilon_0 \sin(\omega t); \quad \text{Coil plane parallel to } \vec{B} \Rightarrow \theta_{\text{normal}} = 90^\circ \Rightarrow \varepsilon = \varepsilon_{\text{max}}$$

Solution:

- When the plane of the coil is parallel to the magnetic field lines, the area normal vector is perpendicular to the field ($\theta = 90^\circ$), making instantaneous flux zero.
- At this geometry, coil sides cut through magnetic field lines perpendicularly at maximum speed, producing the maximum rate of flux change ($d\Phi/dt$) and peak EMF.

Why other options are incorrect:

- Option A:** When the coil plane is perpendicular to $\vec{B}$, flux is maximized but the rate of change is zero, resulting in zero induced EMF.
- Option C:** At 45° , induced EMF is $\varepsilon_0 \sin(45^\circ) \approx 0.707\varepsilon_0$.
- Option D:** At 60° , induced EMF is intermediate and less than the peak value.

Question #170 Key: (A)PHYSICS
15. Atomic Spectra

During electronic transitions between bound atomic energy levels in an atom, which form of elec...

CORE CONCEPT & DERIVATION

Atomic electron transitions involve energy differences on the order of electron-volts (eV) to kiloelectron-volts (keV), whereas gamma rays originate from megaelectron-volt (MeV) intranuclear transitions.

Formula / Rule / Reaction:

$$\Delta E_{\text{atomic}} = h\nu \in [\text{Infrared, Visible, UV, X-rays}]; \quad \Delta E_{\text{nuclear}} \Rightarrow \gamma\text{-rays}$$

Solution:

- Electron transitions between outer or inner atomic shells produce infrared, visible, ultraviolet, or characteristic X-ray photons.
- Gamma rays have energies in the MeV range and originate exclusively from intranuclear rearrangements and nuclear decays, never from electronic transitions.

Why other options are incorrect:

- **Option B:** Low-energy electronic transitions (e.g., Paschen, Brackett series in hydrogen) emit infrared radiation.
- **Option C:** Transitions to the ground state in hydrogen (Lyman series) emit ultraviolet photons.
- **Option D:** Transitions to the second energy level (Balmer series) emit visible light.

Question #171 Key: (C)PHYSICS
09. Current Electricity

Which of the following physical quantities is measured in kilowatt-hours (kWh)?

CORE CONCEPT & DERIVATION

The kilowatt-hour is a commercial unit of energy equal to the total work performed by one kilowatt of power sustained for one hour.

Formula / Rule / Reaction:

$$E = P \times t; \quad 1 \text{ kWh} = (1000 \text{ W}) \times (3600 \text{ s}) = 3.6 \times 10^6 \text{ J} = 3.6 \text{ MJ}$$

Solution:

- Multiplying power (kilowatts) by time (hours) yields an energy quantity.
- Therefore, the kilowatt-hour is an engineering unit of electrical energy consumed.

Why other options are incorrect:

- **Option A:** Electric charge is measured in coulombs (C) or ampere-hours (Ah).
- **Option B:** Electric current is measured in amperes (A).
- **Option D:** Electric power is measured in watts (W) or kilowatts (kW), without the hour unit.

Question #172 Key: (A)PHYSICS
13. Electronics

The opposing conducting plates of a parallel-plate capacitor are physically separated by a layer...

CORE CONCEPT & DERIVATION

A capacitor stores charge electrostatically on conducting plates separated by a non-conducting dielectric medium to prevent charge leakage.

Formula / Rule / Reaction:

$$C = \frac{\epsilon_r \epsilon_0 A}{d}; \quad \text{Dielectric} = \text{Insulator with relative permittivity } \epsilon_r$$

Solution:

- To accumulate and store opposite charges without forming an internal short circuit, the intervening space must be filled with an insulator (dielectric, such as mica, ceramic, paper, or air).

Why other options are incorrect:

- **Option B:** Placing a conductor between the plates discharges the capacitor through direct conduction.
- **Option C:** A semiconductor conducts current under applied voltages, causing leakage.
- **Option D:** A resistor dissipates stored energy as thermal heat.

Question #173 Key: (C)PHYSICS
05. Waves

Stationary (standing) waves cannot transport which of the following through a medium?

CORE CONCEPT & DERIVATION

Standing waves are formed by the superposition of two identical waves traveling in opposite directions, trapping vibrational energy between nodes.

Formula / Rule / Reaction:

$$y(x, t) = 2A \sin(kx) \cos(\omega t); \quad \text{Net energy flux across nodes} = 0$$

Solution:

- Because the constituent traveling waves carry equal energy in opposite directions, there is zero net transfer of energy past nodal points.
- Furthermore, mechanical waves involve localized particle oscillations without net bulk transport of matter (mass).
- Therefore, standing waves transport neither net energy nor mass.

Why other options are incorrect:

- **Option A:** Energy is not the only quantity that is not transported; mass is also not transported.
- **Option B:** Mass is not the only quantity that is not transported; energy is also trapped.
- **Option D:** Phase profiles remain stationary between nodes.

Question #174 Key: (A)PHYSICS
05. Waves

A child swings on a playground swing such that the minimum and maximum heights of the swing sea...

CORE CONCEPT & DERIVATION

In an ideal gravitational pendulum, potential energy lost between the turning point and the lowest point converts completely into kinetic energy.

Formula / Rule / Reaction:

$$\Delta U = \Delta K \implies mg(h_{\max} - h_{\min}) = \frac{1}{2}mv_{\max}^2 \implies v_{\max} = \sqrt{2g\Delta h}$$

Solution:

- Height difference: $\Delta h = 2.0 \text{ m} - 0.75 \text{ m} = 1.25 \text{ m}$.
- Calculate maximum velocity at the lowest point:

$$v_{\max} = \sqrt{2 \times 10 \times 1.25} = \sqrt{25} = 5 \text{ m/s}$$

Why other options are incorrect:

- **Option B:** 10 m/s would require a vertical height drop of $\Delta h = \frac{v^2}{2g} = 100/20 = 5 \text{ m}$.
- **Option C:** 15 m/s requires a vertical drop of 11.25 m.
- **Option D:** 20 m/s requires a vertical drop of 20 m.

Question #175 Key: (B)PHYSICS
11. Electromagnetic Induction

In an electrical transformer, the primary and secondary coils are coupled to each other:

CORE CONCEPT & DERIVATION

Transformers transfer alternating electrical energy between circuits through mutual magnetic induction across a core without galvanic electrical connection.

Formula / Rule / Reaction:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}; \text{ Mutual flux: } \Phi_m \text{ links primary and secondary coils}$$

Solution:

- The primary and secondary windings are electrically insulated from each other.
- They are wound around a common laminated soft iron core that channels alternating magnetic flux to induce an EMF in the secondary winding.

Why other options are incorrect:

- **Option A:** Direct electrical connection is absent in standard isolation transformers (except autotransformers).
- **Option C:** Thermal coupling is an unwanted heat loss mechanism, not the operational coupling principle.
- **Option D:** Transformers are static machines with no rotating mechanical shafts.

Question #176 Key: (B)PHYSICS
08. Electrostatics

To calculate the electric field intensity surrounding an infinitely long uniform line of charge...

CORE CONCEPT & DERIVATION

A Gaussian surface must match the spatial symmetry of the electric field so that field magnitude is uniform and normal to the integration surface.

Formula / Rule / Reaction:

$$\oint \vec{E} \cdot d\vec{A} = E(2\pi rL) = \frac{\lambda L}{\epsilon_0} \implies E = \frac{\lambda}{2\pi\epsilon_0 r}$$

Solution:

- An infinite straight line charge exhibits cylindrical symmetry, with electric field vectors directed radially outward.
- A coaxial cylinder provides a curved surface where E is uniform and perpendicular to the area vector, and flat end-caps through which flux is zero.

Why other options are incorrect:

- **Option A:** A sphere possesses point symmetry suited for isolated point charges.
- **Option C:** A cube has varying distances and angles to a line charge, complicating integration.
- **Option D:** A cuboid lacks the required radial symmetry for flux integration.

Question #177 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Choose the word with the correct spelling:

CORE CONCEPT & DERIVATION

Standard English orthography combines the classical root 'patriarch' with the adjectival suffix '-al'.

Formula / Rule / Reaction:

$$\text{Patriarch} + \text{-al} = \text{Patriarchal}$$

Solution:

- The correct spelling is 'Patriarchal', meaning relating to or characteristic of a system of society or government controlled by men.

Why other options are incorrect:

- **Option B:** 'Patreachal' omits the internal 'i' and misplaces vowels.
- **Option C:** 'Partriarchel' introduces an erroneous 'r' and misspells the suffix as '-el'.
- **Option D:** 'Patriarrchal' erroneously doubles the consonant 'r'.

Question #178 Key: (C)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The antonym of the word 'asylum' is:

CORE CONCEPT & DERIVATION

An antonym is a word that conveys the directly opposite lexical meaning to a given term.

Formula / Rule / Reaction:Asylum (Sanctuary / Safety / Shelter) $\iff$ Antonym: Danger / Peril / Hazard**Solution:**

- 'Asylum' denotes protection, refuge, and safety from harm.
- The direct semantic opposite of safety and refuge is 'danger'.

Why other options are incorrect:

- **Option A:** 'Security' is a synonym of asylum.
- **Option B:** 'Refuge' is a direct synonym of asylum.
- **Option D:** 'Protection' is a defining characteristic and synonym of asylum.

Question #179 Key: (C)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Choose the grammatically correct sentence:

CORE CONCEPT & DERIVATION

In standard English idiom, the adjective 'good' requires the dependent preposition 'at' when describing proficiency in an activity or skill.

Formula / Rule / Reaction:

Subject + be + good at + Gerund/Noun

Solution:

- The correct idiomatic construction for competence in a language or skill is 'good at'.
- Therefore, 'She is good at speaking English' is grammatically correct.

Why other options are incorrect:

- **Option A:** 'Good in' is unidiomatic when referring to dynamic skills or spoken languages.
- **Option B:** 'Good with' is used for people or instruments (e.g., 'good with children', 'good with tools').
- **Option D:** 'Well' is an adverb of manner; using it after the copular linking verb 'is' before 'at speaking' is ungrammatical.

Question #180 Key: (D)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the sentence that exhibits correct punctuation:

CORE CONCEPT & DERIVATION

Punctuation rules require a comma to separate introductory dependent clauses or loosely connected coordinate clauses.

Formula / Rule / Reaction:

Grammatical rule for comma juncture.

Solution:

- A comma is placed after the introductory clause 'It is mentioned in the notification' to provide a pause before the main imperative clause 'all of us should read it'.

Why other options are incorrect:

- **Option A:** Omits the required comma, producing an unpunctuated run-on sentence.
- **Option B:** Lacks punctuation between clauses and uses an inappropriate plural noun.
- **Option C:** Erroneously inserts a question mark after a declarative clause.

Question #181 Key: (B)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Choose the correct verb form to fill in the blank: I _____ with my parents.

CORE CONCEPT & DERIVATION

Subject-verb agreement requires the first-person singular pronoun 'I' to take specific auxiliary verbs in the present continuous tense.

Formula / Rule / Reaction:

Subject (I) + am + V-ing

Solution:

- The pronoun 'I' pairs with the auxiliary 'am' to describe an ongoing state or temporary living arrangement ('am living').

Why other options are incorrect:

- **Option A:** 'Lives' is the third-person singular form (used with he/she/it).
- **Option C:** 'Is living' uses the third-person singular auxiliary 'is', violating agreement with 'I'.
- **Option D:** 'Shall living' is ungrammatical; modal auxiliaries require a bare infinitive (e.g., 'shall live').

Question #182 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Fill in the blank with the most appropriate word: The melody is _____, not energetic like ...

CORE CONCEPT & DERIVATION

Contextual contrast markers (such as 'not like') require an adjective that semantically opposes the referenced quality of being energetic.

Formula / Rule / Reaction:

Contextual semantic contrast.

Solution:

- The sentence contrasts the melody with energetic church hymns.
- 'Plaintive' means sounding sad, mournful, and subdued, providing the appropriate tonal contrast to 'energetic'.

Why other options are incorrect:

- **Option B:** 'Baffling' means confusing or puzzling, which does not describe a musical mood contrasting with energetic.
- **Option C:** 'Blissful' means extremely happy, which does not contrast with energetic.
- **Option D:** 'Perplexing' means complicated and difficult to understand.

Question #183 Key: (D)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Choose the correct tense form to fill in the blank: When I opened my eyes, I _____ a stran...

CORE CONCEPT & DERIVATION

In a temporal clause governed by a simple past verb ('opened'), a completed narrative event in the main clause takes the simple past tense.

Formula / Rule / Reaction:

When + Past Simple $\Rightarrow$ Past Simple (Sequential narrative actions)

Solution:

- The action of opening the eyes is in the simple past ('opened').
- The perception occurred immediately at that past moment, requiring the simple past verb 'saw'.

Why other options are incorrect:

- **Option A:** 'Am seeing' is present continuous, conflicting with the past frame; verbs of perception are also stative.
- **Option B:** 'Have seen' is present perfect, which cannot be used with a specific completed past time clause.
- **Option C:** 'Was seen' is passive voice, which incorrectly makes the subject the object of sight.

Question #184 Key: (B)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Fill in the blanks with the correct verb combination: The neighbours _____ so loudly last ...

CORE CONCEPT & DERIVATION

The adverbial time marker 'last night' establishes a completed past time frame, requiring consistent past tenses.

Formula / Rule / Reaction:

Past Continuous (ongoing background action) + Past Simple (consequent result)

Solution:

- 'Were shouting' describes the ongoing past disturbance during the night.
- 'Kept' expresses the completed consequence of keeping everyone awake until midnight.

Why other options are incorrect:

- **Option A:** 'Are shouting / are keeping' uses present tenses, contradicting the past temporal anchor 'last night'.
- **Option C:** 'Have been keeping' is present perfect continuous, which cannot coordinate with 'last night'.
- **Option D:** 'Have shouted' is present perfect, which cannot refer to a specific past time.

Question #185 Key: (A)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Which of the following verb forms correctly fills in the blank? Bread and butter is what the po...

CORE CONCEPT & DERIVATION

The construction 'the + adjective' functions as a plural collective nominal phrase denoting a whole class of people and takes a plural verb.

Formula / Rule / Reaction:

'The poor' = Poor people (Plural subject) $\Rightarrow$ Plural verb (need)

Solution:

- In this sentence, 'the poor' refers collectively to impoverished people.
- Because 'the poor' is grammatically plural, it takes the base plural verb 'need' in the simple present tense.

Why other options are incorrect:

- **Option B:** 'Needs' is the singular verb form, which violates agreement with the plural collective noun 'the poor'.
- **Option C:** 'Needed' is past tense, conflicting with the present temporal adverb 'today'.
- **Option D:** 'Needing' is a participle that lacks an auxiliary verb.

Question #186 Key: (D)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Correct the run-on comma splice in the given sentence: *I like cats, I hate dogs.*

CORE CONCEPT & DERIVATION

Two independent clauses expressing contrasting propositions cannot be joined by a comma alone; they require a coordinating conjunction.

Formula / Rule / Reaction:

Clause₁ + Adversative Conjunction (but) + Clause₂

Solution:

- The original sentence commits a comma splice by joining two independent clauses without a coordinating conjunction.
- Inserting the adversative conjunction 'but' correctly links the contrasting statements.

Why other options are incorrect:

- **Option A:** A colon is used to introduce an explanation, list, or amplification, not a contrasting clause.
- **Option B:** Omitting punctuation creates a fused run-on sentence.
- **Option C:** An apostrophe indicates possession and is ungrammatical here.

Question #187 Key: (B)ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

Choose the sentence that conveys the same meaning as the following sentence: *I will not tolerate...*

CORE CONCEPT & DERIVATION

Phrasal verbs rely on fixed prepositional collocations to convey specific idiomatic meanings.

Formula / Rule / Reaction:

To put up with $\equiv$ To tolerate / endure / bear

Solution:

- The three-part phrasal verb 'put up with' means to tolerate or endure someone or something unpleasant.
- Therefore, 'I will not put up with his rudeness' accurately matches 'I will not tolerate his rudeness'.

Why other options are incorrect:

- **Option A:** 'Put up for' means to offer oneself or someone as a candidate or for accommodation.
- **Option C:** 'Put up to' means to encourage or incite someone to do something mischievous.
- **Option D:** 'Put up by' is an unidiomatic combination in English.

Question #188 Key: (A)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Which of the following sentences is grammatically correct?

CORE CONCEPT & DERIVATION

Indefinite singular countable nouns require an indefinite article ('a') when referring to any representative individual of a class.

Formula / Rule / Reaction:

Indefinite general reference: 'a person' + Singular verb ('says', 'comes', 'has')

Solution:

- Option A uses the indefinite article 'a' to refer to human beings in general ('a person') and maintains proper subject-verb agreement ('says', 'comes', 'has').

Why other options are incorrect:

- **Option B:** 'The person' specifies a particular individual rather than stating a universal truth about humankind.
- **Option C:** Omits the required article before the singular countable noun 'person'.
- **Option D:** Uses the plural verb 'say' with the singular proper noun 'The Bible'.

Question #189 Key: (C)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Identify the part of the following sentence that contains a grammatical error: *I think it is th...*

CORE CONCEPT & DERIVATION

In a relative clause introduced by 'who', the verb must agree in person and number with the antecedent pronoun.

Formula / Rule / Reaction:

Antecedent (they, plural) + who + are (plural verb)

Solution:

- In the cleft construction 'it is they who is wrong', the relative pronoun 'who' refers back to the plural subjective pronoun 'they'.
- Therefore, the relative clause requires the plural verb 'are' ('who are wrong') instead of the singular 'is'.

Why other options are incorrect:

- **Option A:** 'it' is the correct dummy pronoun for the cleft sentence.
- **Option B:** 'who' is the correct relative pronoun referring to persons.
- **Option D:** 'wrong' is the correct predicate adjective.

Question #190 Key: (D)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Identify the correct spelling of the astronomical galaxy name:

CORE CONCEPT & DERIVATION

Standard astronomical names derived from Greek mythology follow fixed classical orthography.

Formula / Rule / Reaction:

Factual recall / Correct orthography.

Solution:

- The correct spelling is 'Andromeda' (Messier 31), referring to the barred spiral galaxy nearest to the Milky Way.

Why other options are incorrect:

- Option A:** 'Andoromeda' inserts an erroneous extra vowel 'o'.
- Option B:** 'Andromida' replaces the second 'e' with 'i'.
- Option C:** 'Andremode' transposes vowels and distorts the terminal syllables.

Question #191 Key: (B)ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

Fill in the blank with the appropriate preposition: Do not hanker _____ worldly pleasures.

CORE CONCEPT & DERIVATION

Certain English verbs require fixed prepositions to form standard idiomatic collocations.

Formula / Rule / Reaction:Hanker after / for $\Rightarrow$ 'After' is the preferred standard classical MDCAT idiom**Solution:**

- The verb 'hanker' means to have a strong, persistent longing or desire.
- It idiomatically pairs with the preposition 'after' in formal English literature and textbook past paper keys ('hanker after worldly pleasures').

Why other options are incorrect:

- Option A:** While 'hanker for' appears colloquially, 'hanker after' is the standard past paper idiom.
- Option C:** 'Towards' indicates physical or directional orientation, not longing.
- Option D:** 'About' is unidiomatic with the verb hanker.

Question #192 Key: (B)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Fill in the blank with the correct choice: Whatever she wants to do _____ fine with me.

CORE CONCEPT & DERIVATION

A nominal noun clause functioning as the subject of a sentence takes a singular verb.

Formula / Rule / Reaction:Noun Clause [Whatever she wants to do] = Singular Subject $\Rightarrow$ Singular Verb ('is')**Solution:**

- The dependent clause 'Whatever she wants to do' serves as the singular grammatical subject of the sentence.
- Nominal clauses take singular agreement, requiring the singular verb 'is'.

Why other options are incorrect:

- Option A:** 'the' is a definite article, not a finite verb.
- Option C:** 'are' is plural, which violates agreement with a singular noun clause.
- Option D:** 'were' is plural past subjunctive, which does not fit this indicative present sentence.

Question #193 Key: (B)ENGLISH
01. Vocabulary, Synonyms, Antonyms & SpellingThe vocabulary word *INCLUSIVE* is closest in meaning to:**CORE CONCEPT & DERIVATION**

Synonyms are words sharing closely related core semantic definitions.

Formula / Rule / Reaction:Inclusive (containing or encompassing everything) $\equiv$ Comprehensive (all-embracing)**Solution:**

- 'Inclusive' means containing all expected elements or covering an entire range.
- 'Comprehensive' similarly denotes including or dealing with all or nearly all elements or aspects of something.

Why other options are incorrect:

- Option A:** 'Exclusive' is an antonym meaning restricted or shutting out other things.
- Option C:** 'Diverse' means showing variety, which is distinct from being all-inclusive.
- Option D:** 'Embracing' is a participial form that does not serve as a direct formal equivalent to the adjective 'inclusive'.

Question #194 Key: (C)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

What does the word 'outmoded' mean in the following sentence? The designer window treatments in...

CORE CONCEPT & DERIVATION

Context clues related to elapsed time ('installed 17 years ago') clarify adjectives describing outdated style or fashion.

Formula / Rule / Reaction:

Outmoded $\equiv$ Old-fashioned / Out-of-date / Antiquated

Solution:

- 'Outmoded' describes something that is no longer in fashion, style, or modern use.
- In this context, window decor installed 17 years ago is described as 'out-of-date'.

Why other options are incorrect:

- Option A:** 'Unnecessary' means not needed, which does not address whether something is out of style.
- Option B:** 'Pointless' means having no purpose.
- Option D:** 'Worthless' means having no financial or practical value, which is not the definition of outmoded.

Question #195 Key: (A)LOGICAL REASONING
05. Categorical Syllogisms & Overlapping Sets

Read the statements and determine which conclusions necessarily follow: Statements: I. All chil...

CORE CONCEPT & DERIVATION

Categorical syllogisms are evaluated using standard conversion and deduction rules on set relationships.

Formula / Rule / Reaction:

Conversion: 'All A are B' $\implies$ 'Some B are A'; Some B are C + All C are D $\implies$ Some B are D

Solution:

- Conclusion I: Statement 1 states 'All children are silly people'. By standard subaltern conversion, 'Some silly people are children' is necessarily true.
- Conclusion II: Statement 2 states 'Some silly people are rich people'. This subset of silly people might not overlap with children; therefore, Conclusion II is not necessarily true.
- Conclusion III: 'Some silly people are rich' and 'All rich people are big shots'. The silly people who are rich must also be big shots, making 'Some silly people are big shots' necessarily true.
- Therefore, Conclusions I and III necessarily follow.

Why other options are incorrect:

- Option B:** Conclusion II does not follow from the premises.
- Option C:** Incorrect because Conclusion II is not guaranteed.
- Option D:** Incorrect because Conclusion II is not guaranteed while Conclusion III is valid.

Question #196 Key: (B)LOGICAL REASONING
11. Set Theory, Integer Bounds & Arithmetic

X, Y, and Z are three whole numbers strictly greater than 23 and strictly less than 31 (i.e., f...

CORE CONCEPT & DERIVATION

Deductive constraints must satisfy bounded domain conditions alongside prime, parity, and ordering criteria.

Formula / Rule / Reaction:

Allowed Range: {24, 25, 26, 27, 28, 29, 30}

Solution:

- Prime numbers strictly between 23 and 31: The only prime in this range is 29; therefore, $X = 29$.
- Odd numbers in this range: {25, 27, 29}. The largest odd number is 29; therefore, $Y = 29$.
- Even numbers in this range: {24, 26, 28, 30}. The smallest even number is 24; therefore, $Z = 24$.
- The unique solution is $X = 29, Y = 29, Z = 24$.

Why other options are incorrect:

- Option A:** $X = 31$ violates the condition that numbers must be strictly less than 31.
- Option C:** $X = 23$ violates the condition that numbers must be strictly greater than 23.
- Option D:** 27 is composite (3×9), not prime, and $Y = 31$ falls outside the permitted range.

Question #197 Key: (A)LOGICAL REASONING
03. Courses of Action & Decision-Making

Read the statement and decide which suggested course(s) of action logically follow: Statement: ...

CORE CONCEPT & DERIVATION

A logical course of action must be a proportionate, corrective, and effective administrative response that addresses persistent misconduct.

Formula / Rule / Reaction:

Logical evaluation of administrative course of action.

Solution:

- Because this is the third repeated offense in a professional examination, warnings have proven ineffective.
- Disciplinary action (removing the student and canceling the examination attempt) is the appropriate, standard response to repeated cheating (Course I).
- Issuing another warning (Course II) is an ineffective response to chronic, repeated cheating.

Why other options are incorrect:

- **Option B:** A warning alone fails to uphold examination integrity for a third-time offense.
- **Option C:** Actions I and II are mutually contradictory; one cannot cancel the exam while merely issuing another warning.
- **Option D:** Action I is standard administrative procedure and must be pursued.

Question #198 Key: (D)LOGICAL REASONING
05. Categorical Syllogisms & Overlapping Sets

Analyze the following premises and determine which conclusion logically follows: Statements: 1....

CORE CONCEPT & DERIVATION

In formal logic, two premises with an undistributed middle term cannot support a valid conclusion connecting the extreme terms.

Formula / Rule / Reaction:

Fallacy of the Undistributed Middle: All A are B + Some B are C \(\text{center not}\) $\Rightarrow$ C

Solution:

- The middle term 'professionals' is undistributed in both premises: it is the predicate of an affirmative universal premise (All D are P) and the subject of a particular premise (Some P are W).
- The wealthy professionals could be lawyers or accountants, without any overlap with doctors.
- Because no necessary relationship between 'doctors' and 'wealthy' is established, no definite conclusion follows.
- *Note on archive heal:* Transcribed transcripts truncated Option D to 'All'; the authentic logical conclusion is 'None of these follows'.

Why other options are incorrect:

- **Option A:** The premises provide no evidence that every doctor is wealthy.
- **Option B:** An overlap between doctors and wealthy professionals is possible, but not logically necessary.
- **Option C:** The premises do not exclude doctors from being wealthy.

Question #199 Key: (A)LOGICAL REASONING
08. Letter Series & Coding-Decoding

In a certain code language, 'TRAIN' is written as 'UQBHO'. Using the same encoding rule, how is...

CORE CONCEPT & DERIVATION

Letter-coding ciphers follow regular mathematical shift patterns applied sequentially across character positions.

Formula / Rule / Reaction:

Shifts: (+1, -1, +1, -1, +1)

Solution:

- Analyze the cipher pattern in 'TRAIN' → 'UQBHO':
- T (+1) → U
- R (-1) → Q
- A (+1) → B
- I (-1) → H
- N (+1) → O
- Apply this alternating (+1, -1, +1, -1, +1) pattern to 'PLANE':
- P (+1) → Q
- L (-1) → K
- A (+1) → B
- N (-1) → M
- E (+1) → F
- The resulting encoded word is QKBMF.

Why other options are incorrect:

- Option B:** QKBOD applies incorrect shifts to the final letters.
- Option C:** OKZMF applies a -1 shift to the first letter instead of +1.
- Option D:** QMBOF fails to decrement L and N properly.

Question #200 Key: (D)LOGICAL REASONING
07. Number Series & Numerical Progressions

Find the next number in the numerical series: 3, 8, 15, 24, 35, ?

CORE CONCEPT & DERIVATION

Polynomial number series can be solved by analyzing consecutive first differences or algebraic index relations.

Formula / Rule / Reaction:

$$T_n = n^2 - 1 \quad (\text{for } n \geq 2) \quad \text{or} \quad T_n = T_{n-1} + (2n + 1)$$

Solution:

- Method 1 (Differences between consecutive terms):
- $8 - 3 = 5$
- $15 - 8 = 7$
- $24 - 15 = 9$
- $35 - 24 = 11$
- The differences increase by 2 each step (5, 7, 9, 11). The next difference must be $11 + 2 = 13$.
- Next term: $35 + 13 = 48$.
- Method 2 (Algebraic relation $n^2 - 1$):
- $2^2 - 1 = 3, 3^2 - 1 = 8, 4^2 - 1 = 15, 5^2 - 1 = 24, 6^2 - 1 = 35, 7^2 - 1 = 48$.

Why other options are incorrect:

- Option A:** 45 adds only 10 instead of 13.
- Option B:** 46 adds 11, failing to increment the step difference.
- Option C:** 47 adds 12 instead of the required odd integer 13.