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UHS LAHORE

UHS Lahore MDCAT 2022 Official Paper

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

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

What does the term bacteriophage refer to?

- (A) A virus that infects bacteria
- (B) A bacterium that infects viruses
- (C) A virus that behaves as a bacterium
- (D) A combination of bacterium and virion

Q2. BIO

Which of the following viruses contains single-stranded DNA?

- (A) Adenovirus
- (B) Herpes virus
- (C) Parvovirus
- (D) Pox virus

Q3. BIO

How many tail fibrils are attached to the end plate of a bacteriophage?

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

Q4. BIO

The enzymes integrase, protease, and reverse transcriptase are found in which virus?

- (A) Hepatitis A virus
- (B) Herpes virus
- (C) Influenza virus
- (D) Human immunodeficiency virus

Q5. BIO

What is the end product of glucose by yeast in anaerobic respiration?

- (A) Ethanol and oxygen
- (B) Ethanol and water
- (C) Ethanol and CO₂
- (D) Lactic acid and CO₂

Q6. BIO

Each carrier in the electron transport chain is first _____ and then _____.

- (A) Broken-down, regenerated
- (B) Generated, broken-down
- (C) Oxidized, reduced
- (D) Reduced, oxidized

Q7. BIO

The electron transport chain explains:

- (A) Photophosphorylation
- (B) Z-scheme
- (C) Photolysis
- (D) Mechanism of ATP synthesis

Q8. BIO

What is the color of the chlorophyll-b molecule?

- (A) Bluish-green
- (B) Yellowish-green
- (C) Dark green
- (D) Reddish-green

Q9. BIO

Upon initial hydrolysis, starch yields:

- (A) Glucose
- (B) Maltose
- (C) Sucrose
- (D) Mannose

Q10. BIO

Human bone cells contain _____ % of water.

- (A) 20
- (B) 40
- (C) 85
- (D) 90

Q11. BIO

The unique three-dimensional shape of the fully folded polypeptide constitutes the:

- (A) Primary structure of protein
- (B) Secondary structure of protein
- (C) Tertiary structure of protein
- (D) Quaternary structure of protein

Q12. BIO

Butyric acid is a _____ carbon fatty acid.

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

Q13. BIO

Which of the following is a conjugated molecule?

- (A) Protein
- (B) Lipid
- (C) Glycoproteins
- (D) Vitamins

Q14. BIO

The hydrolysis process is the reverse of which process?

- (A) Photolysis
- (B) Condensation
- (C) Deduction
- (D) Convection

Q15. BIO

Proteins are the main _____ of the cell.

- (A) Physiological components
- (B) Functional components
- (C) Structural components
- (D) Biological components

Q16. BIO

The cell wall may be absent in which of the following?

- (A) Plants and Algae
- (B) Algae and Fungi
- (C) Fungi and Archaea
- (D) Bacteria and Archaea

Q17. BIO

_____ are the structures formed by invagination of the plasma membrane and have been associated with cell division and DNA replication in prokaryotic cells.

- (A) Lysosomes
- (B) Mesosomes
- (C) Golgi bodies
- (D) Phragmoplasts

Q18. BIO

Which of the following are single-membranous organelles?

- (A) Mitochondria and ribosomes
- (B) Cytosol, mitochondria, and ribosomes
- (C) Golgi bodies, lysosomes, and endoplasmic reticulum
- (D) Golgi bodies, lysosomes, and mitochondria

Q19. BIO

Movement of molecules against the concentration gradient is termed:

- (A) Passive transport
- (B) Active transport
- (C) Facilitated diffusion
- (D) Filtration

Q20. BIO

The digestive vacuoles and autophagosomes are also known as:

- (A) Phagocytosis vesicles
- (B) Primary lysosomes
- (C) Secondary lysosomes
- (D) Peroxisomes

Q21. BIO

The cell wall of bacteria is composed of:

- (A) Chitin
- (B) Murein
- (C) Cellulose
- (D) Hemicellulose

Q22. BIO

Which one of the following is common to both prokaryotic and eukaryotic cells?

- (A) Cytoplasmic streaming movement
- (B) Ribosome
- (C) Binary fission
- (D) Nuclear envelope

Q23. BIO

There is no clear morphological difference between dendrites and axons in sensory neurons, except for their:

- (A) Thickness
- (B) Length
- (C) Terminal portions
- (D) Myelination

Q24. BIO

The neurotransmitter active outside the Central Nervous System (CNS) is:

- (A) Acetylcholine
- (B) Dopamine
- (C) Glutamate
- (D) Serotonin

Q25. BIO

A hormone that plays a major role in social bonding, childbirth, milk ejection, and sexual reproduction is:

- (A) Estrogen
- (B) Oxytocin
- (C) Prolactin
- (D) Secretin

Q26. BIO

Which hormone is produced by the human placenta?

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

Q27. BIO

The middle layer of the meninges is the:

- (A) Arachnoid mater
- (B) Pia mater
- (C) Dura mater
- (D) Cranium

Q28. BIO

The part of the brain that guides smooth and accurate motions and maintains body posture is the:

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

Q29. BIO

A water vascular system (ambulacral system) is a unique and complex organ system found specifically in:

- (A) Sponges
- (B) Arthropods
- (C) Echinoderms
- (D) Fishes

Q30. BIO

Roundworms belong to which phylum?

- (A) Annelida
- (B) Coelenterata
- (C) Nematoda
- (D) Platyhelminthes

Q31. BIO

A silverfish is classified as a/an:

- (A) Insect
- (B) Mollusc
- (C) Jawless fish
- (D) Cartilaginous fish

Q32. BIO

True tissues are absent in which of the following animal groups?

- (A) Flatworms
- (B) Sponges
- (C) Cnidarians
- (D) Roundworms

Q33. BIO

Enzymes lower the activation energy by stabilizing the transition state of a metabolic reaction primarily due to:

- (A) Changing conditions within the active site
- (B) Changing conditions within the protein framework
- (C) Rearranging fatty acids in the active site
- (D) Distorting molecules in the allosteric site

Q34. BIO

Competitive inhibitors compete with the:

- (A) Enzyme
- (B) Substrate
- (C) Product
- (D) Coenzyme

Q35. BIO

Non-competitive inhibitor molecules have:

- (A) A similar structure to the normal substrate molecule
- (B) A quite different structure from the substrate molecule
- (C) A different conformation but fit into the active site
- (D) A similar conformation but do not fit into the active site

Q36. BIO

A zinc ion is attached at the active site of the enzyme carboxypeptidase. The zinc ion functions as:

- (A) A coenzyme molecule
- (B) An activator
- (C) An inhibitor molecule
- (D) A controller of the allosteric site

Q37. BIO

What is the optimum physiological pH range for most human cellular enzymes?

- (A) 2 to 3
- (B) 3 to 5
- (C) 6 to 8
- (D) 8 to 10

Q38. BIO

Adaptations that an organism acquires by its own actions during its lifespan without modifying its genome are:

- (A) Heritable
- (B) Non-heritable
- (C) Can be made heritable through somatic modification
- (D) Sometimes heritable and other times non-heritable

Q39. BIO

For the evolutionary process of allopatric speciation to occur, which of the following is NOT a geographical barrier?

- (A) Ocean
- (B) River
- (C) Mountain
- (D) Atmosphere

Q40. BIO

According to the Biogenetic Law of Ernst Haeckel:

- (A) There is survival of the fittest
- (B) There is use and disuse of organs
- (C) Phylogeny recapitulates ontogeny
- (D) Ontogeny recapitulates phylogeny

Q41. BIO

The animal species on the Galapagos Islands most closely resemble species living on the:

- (A) Northern Europe mainland
- (B) Great Britain mainland
- (C) North American mainland
- (D) South American mainland

Q42. BIO

Digested food from the small intestine is carried directly to the liver by the:

- (A) Hepatic artery
- (B) Hepatic vein
- (C) Hepatic portal vein
- (D) Hepatic portal artery

Q43. BIO

_____ proteins are produced by white blood cells in response to _____ and provide humoral immunity.

- (A) Antibiotics, antigens
- (B) Antibodies, RBCs
- (C) Globulins, histamine
- (D) Antibodies, antigens

Q44. BIO

The lymphatic vessels of the body empty lymph into the bloodstream at the:

- (A) Abdominal vein
- (B) Jugular vein
- (C) Subclavian vein
- (D) Bile duct

Q45. BIO

Flow of blood entering the capillaries is adjusted by:

- (A) Heart directly
- (B) Pre-capillary sphincters
- (C) Meta-arterioles
- (D) Venous valves

Q46. BIO

The pressure exerted by a solution separated by a semipermeable membrane from pure water is termed:

- (A) Osmotic pressure
- (B) Soil potential
- (C) Solute potential
- (D) Solvent potential

Q47. BIO

Which of the following is NOT a consequence of anaerobic respiration in human muscle cells?

- (A) Muscle cramps
- (B) High consumption of energy
- (C) Muscle pain
- (D) Tiredness and fatigue

Q48. BIO

Respiratory surfaces across animals exhibit which of the following mandatory characteristics?

- (A) It must be permeable
- (B) It must be thick for low diffusion
- (C) It should be non-vascularized
- (D) It should have a low ventilation mechanism

Q49. BIO

Which of the following organisms is a prokaryote?

- (A) Protista
- (B) *Escherichia coli*
- (C) *Amoeba*
- (D) Fungi

Q50. BIO

What is the number of distinct structural layers present in the Gram-negative bacterial cell wall?

- (A) One
- (B) Two
- (C) Three
- (D) Four

Q51. BIO

The division of cocci in three perpendicular planes forms a sarcina, which is a cubical packet of how many cocci?

- (A) 2
- (B) 4
- (C) 8
- (D) 16

Q52. BIO

Which of the following statements is correct regarding human pulmonary ventilation at rest?

- (A) Inspiration is an active process
- (B) Expiration is an active process
- (C) Inspiration is a passive process
- (D) Both expiration and inspiration are passive processes

Q53. BIO

Nitrifying bacteria are classified physiologically as:

- (A) Heterotrophic bacteria
- (B) Chemosynthetic bacteria
- (C) Saprophytic bacteria
- (D) Parasitic bacteria

Q54. BIO

Each human testis is divided by fibrous septa into approximately:

- (A) 50 to 100 lobules
- (B) 150 to 200 lobules
- (C) 200 to 250 lobules
- (D) 250 to 300 lobules

Q55. BIO

Which cells in human males are responsible for the secretion of testosterone?

- (A) Pituitary cells
- (B) Hypothalamic neurons
- (C) Sertoli cells
- (D) Leydig cells (interstitial cells)

Q56. BIO

The fertilized ovum is implanted and undergoes embryonic development within the:

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

Q57. BIO

The blood concentration of luteinizing hormone (LH) reaches its maximum peak during which stage of the menstrual cycle?

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

Q58. BIO

The major mode of transmission of syphilis is:

- (A) Blood transfusion
- (B) Insect bite
- (C) Contaminated water
- (D) Sexual contact

Q59. BIO

Which of the following statements is FALSE regarding cartilage?

- (A) There are many blood vessels in cartilage
- (B) It is a form of connective tissue
- (C) It covers ends of the bones at joints
- (D) It is much softer than bone

Q60. BIO

Which of the following muscle components serves as a high-energy phosphate reservoir for rapid ATP regeneration?

- (A) ATP
- (B) Creatine phosphate
- (C) Myoglobin
- (D) Creatinine phosphate

Q61. BIO

Which of the following is NOT found within skeletal muscle fibers in humans?

- (A) Multiple nuclei
- (B) Multiple mitochondria
- (C) Large amount of myoglobin
- (D) Large amount of hemoglobin

Q62. BIO

A hinge joint is present between which of the following articulating bones?

- (A) Humerus and radio-ulna
- (B) Femur and pectoral girdle
- (C) Femur and acetabulum
- (D) Humerus and pectoral girdle

Q63. BIO

A test cross is performed to determine whether an individual displaying a dominant phenotype is homozygous or heterozygous. Which of the following represents a test cross?

- (A) Unknown phenotype $\times$ At
- (B) Unknown genotype $\times$ tt
- (C) Unknown genotype $\times$ AB
- (D) Unknown genotype $\times$ TT

Q64. BIO

What clinical complication can occur when an Rh^- -negative woman conceives a child who is Rh^+ -positive by an Rh^+ -positive father?

- (A) Maternal-fetal Rh incompatibility
- (B) Paternal-fetal incompatibility
- (C) Cancer of the fetus
- (D) Immediate death of the mother

Q65. BIO

DNA stores hereditary biological information in discrete functional units termed:

- (A) Genes
- (B) Phenotypes
- (C) Karyotypes
- (D) Cells

Q66. BIO

In his studies on sex linkage in *Drosophila melanogaster*, Thomas Hunt Morgan crossed white-eyed males (X^wY) with wild-type homozygous red-eyed females ($X^{w+}X^{w+}$). What was the observed phenotype of the F_1 offspring?

- (A) All red-eyed males and females
- (B) Red-eyed females and white-eyed males
- (C) White-eyed females and red-eyed males
- (D) All white-eyed females and males

Q67. BIO

Which one of the following human genetic conditions is inherited as an X-linked dominant disorder?

- (A) Hemophilia A
- (B) Red-green color blindness
- (C) Hypophosphatemic rickets
- (D) Becker muscular dystrophy

Q68. BIO

The mode of inheritance of genetic traits in humans cannot be studied by controlled experimental crosses and is therefore traced through:

- (A) Experimental mating
- (B) Chi-square analysis
- (C) Pedigree analysis
- (D) Probability analysis

CHEM SECTION: CHEMISTRY

Questions 69 to 122 (54 MCQs)

Q69. CHEM

One atomic mass unit (a.m.u.) is defined as:

- (A) The mass of an atom of ^{12}C
- (B) $\frac{1}{12}$ th the mass of a ^{12}C atom
- (C) $\frac{1}{12}$ th the mass of a ^1H atom
- (D) The mass of one atom of every chemical element

Q70. CHEM

A compound of sodium oxide contains 74.2% sodium and 25.8% oxygen by mass. What is the empirical formula of the compound?

- (A) NaO
- (B) NaO₂
- (C) Na₂O
- (D) Na₂O₂

Q71. CHEM

A sample of 30.0 g of 2-propanol was oxidized with excess acidified $\text{K}_2\text{Cr}_2\text{O}_7$ under reflux. The organic product (propanone) was isolated by distillation with a percentage yield of 75.0%. What was the mass of product obtained?

- (A) 1.74 g
- (B) 21.75 g
- (C) 2.74 g
- (D) 29.0 g

Q72. CHEM

According to which scientist is the wave mechanical probability of finding an electron at a specific position in space formulated?

- (A) Bohr
- (B) De Broglie
- (C) Hund
- (D) Schrodinger

Q73. CHEM

Which gas present in a gas discharge tube produces the lightest canal ray particles (positive ions)?

- (A) Ar
- (B) He
- (C) H₂
- (D) Ne

Q74. CHEM

Which chemical element possesses the ground state electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6$?

- (A) Ar
- (B) Cl
- (C) Na
- (D) S

Q75. CHEM

What is the atomic number (Z) of a transition metal element that contains four unpaired electrons in its ground state?

- (A) 6
- (B) 14
- (C) 22
- (D) 26

Q76. CHEM

A gaseous mixture contains 9.6% NH_3 , 22.6% N_2 , and 67.8% H_2 by volume. If the total pressure is 50 atm, the partial pressure of H_2 is given by:

- (A) $\frac{67.8 \times 100}{50}$
- (B) $\frac{50 \times 100}{100}$
- (C) $\frac{67.8 \times 50}{100}$
- (D) $\frac{67.8 + 50}{100}$

Q77. CHEM

If we want to raise the temperature of one mole of an ideal gas by one Kelvin at constant pressure, how much work energy is expended by the gas?

- (A) 0.0821 J
- (B) $8.314 \text{ dm}^3 \cdot \text{atm}$
- (C) 0.0821 kJ
- (D) $0.0821 \text{ dm}^3 \cdot \text{atm}$

Q78. CHEM

Heat flow between two interacting gases continues until all molecules in both systems attain the same average:

- (A) Translational kinetic energy
- (B) Rotational kinetic energy
- (C) Translational potential energy
- (D) Vibrational kinetic energy

Q79. CHEM

Variation in the strength of intermolecular dipole–dipole forces directly alters many bulk physical properties of liquids. Which of the following properties is NOT affected by the strength of dipole–dipole forces?

- (A) Boiling point
- (B) Heat of vaporization
- (C) Heat of sublimation
- (D) Moles

Q80. CHEM

Which of the following factors does NOT affect the magnitude of the equilibrium vapor pressure of a pure liquid?

- (A) Amount of liquid
- (B) Size of the molecules
- (C) Temperature of the liquid
- (D) Intermolecular forces

Q81. CHEM

The smallest fundamental repeating geometric block that contains the complete structural and symmetry information of a crystal lattice is called the:

- (A) Cell
- (B) Unit cell
- (C) Crystal lattice
- (D) Crystal unit

Q82. CHEM

Which class of crystalline solids is also categorized as atomic network solids?

- (A) Covalent solids
- (B) Ionic solids
- (C) Metallic solids
- (D) Molecular solids

Q83. CHEM

The decrease in the solubility of a sparingly soluble salt caused by the addition of a soluble electrolyte containing an identical ion is known as the:

- (A) Le Chatelier principle
- (B) Solubility product
- (C) Common ion effect
- (D) Distribution law

Q84. CHEM

Precipitation of a sparingly soluble salt from solution occurs when the ionic product (Q_{sp}) is:

- (A) Less than K_{sp}
- (B) Greater than K_{sp}
- (C) Equal to K_{sp}
- (D) At any arbitrary non-zero concentration

Q85. CHEM

The direction in which a chemical equilibrium shifts in response to a change in concentration, temperature, or pressure is predicted by:

- (A) Le Chatelier's principle
- (B) Law of mass action
- (C) Hess's law
- (D) Law of heat of formation

Q86. CHEM

What is the overall reaction order for the rate equation:

$$\text{Rate} = k[\text{H}_2][\text{NO}_2]^2?$$

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

Q87. CHEM

Catalysis in which the catalyst and the reacting chemical species exist in the same physical phase is termed:

- (A) Heterogeneous catalysis
- (B) Homogeneous catalysis
- (C) Enzymatic adsorption catalysis
- (D) Autocatalysis

Q88. CHEM

The Born–Haber cycle used to evaluate the lattice energies of ionic crystals represents an experimental application of:

- (A) Henry's law
- (B) Le Chatelier's principle
- (C) Hess's law
- (D) The common ion effect

Q89. CHEM

Which of the following thermodynamic quantities is a state function?

- (A) Work done
- (B) Heat absorbed
- (C) Frictional dissipation
- (D) Enthalpy

Q90. CHEM

The operation of an electrochemical cell (galvanic or electrolytic) is fundamentally based upon which type of chemical reaction?

- (A) Acid-base neutralization
- (B) Redox reaction
- (C) Nuclear transmutation
- (D) Precipitation reaction

Q91. CHEM

In which of the following chemical compounds does oxygen exhibit a fractional oxidation state?

- (A) OF_2
- (B) Na_2O_2
- (C) KO_2
- (D) Cl_2O_7

Q92. CHEM

Which of the following alkali metal elements has the smallest atomic radius?

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

Q93. CHEM

Among the chlorides LiCl , BeCl_2 , NaCl , and CsCl , the compounds possessing the greatest and the least ionic character, respectively, are:

- (A) LiCl and CsCl
- (B) NaCl and LiCl
- (C) CsCl and NaCl
- (D) CsCl and BeCl_2

Q94. CHEM

Which statement correctly describes the transformation of magnesium atoms during ionic bond formation with chlorine?

- (A) The change is reduction, because there has been a gain of electrons
- (B) The change is oxidation, because there has been a loss of electrons
- (C) The change is reduction, because there has been a loss of electrons
- (D) The change is oxidation, because there has been a gain of electrons

Q95. CHEM

According to VSEPR theory, an AB_4 molecule with no lone pairs around the central atom adopts which molecular geometry?

- (A) Trigonal planar
- (B) Regular tetrahedron
- (C) Regular octahedron
- (D) Trigonal pyramidal

Q96. CHEM

Why does aluminum chloride form a stable dimer (Al_2Cl_6) in the vapor phase?

- (A) Aluminum is electron-rich
- (B) Aluminum has lone pairs of electrons
- (C) Aluminum donates lone pairs to form bridges
- (D) Aluminum forms coordinate covalent bonds with chlorine to complete its octet

Q97. CHEM

Which group of the periodic table contains non-metals, metalloids, and metals among its members?

- (A) Group I-B
- (B) Group VII-A (Group 17)
- (C) Group IV-A (Group 14)
- (D) Group VI-A (Group 16)

Q98. CHEM

Which of the following alkaline earth metal sulfates is virtually insoluble in water?

- (A) BeSO_4
- (B) BaSO_4
- (C) MgSO_4
- (D) CaSO_4

Q99. CHEM

Which of the following coordination complexes exhibits tetrahedral geometry?

- (A) $[\text{Fe}(\text{CO})_5]$
- (B) $[\text{Cu}(\text{CN})_4]^{2-}$
- (C) $[\text{AuCl}_4]^-$
- (D) $[\text{Pt}(\text{NH}_3)_4]^{2+}$

Q100. CHEM

In which pair of 3d-transition elements does one element have all unpaired d-orbitals while the other has all paired d-orbitals in its ground state?

- (A) Cu and Zn
- (B) Cr and Fe
- (C) Cr and Cu
- (D) Mn and Co

Q101. CHEM

In which of the following functional groups is the central carbon atom sp hybridized?

- (A) $-\text{CHO}$
- (B) $-\text{COOH}$
- (C) $-\text{CN}$
- (D) $-\text{COOR}$

Q102. CHEM

Organic compounds containing the $-\text{SH}$ functional group are systematically classified as:

- (A) Alcohols
- (B) Thio-alcohols
- (C) Thio-ethers
- (D) Nitriles

Q103. CHEM

What is the total number of structural and geometric isomers possible for a hydrocarbon having the molecular formula C_4H_8 ?

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

Q104. CHEM

An alkylbenzene is formed when benzene is treated with an alkyl halide in the presence of anhydrous aluminum chloride. Identify this type of organic reaction:

- (A) Halogenation
- (B) Friedel-Crafts acylation reaction
- (C) Friedel-Crafts alkylation reaction
- (D) Sulphonation

Q105. CHEM

Three alternating single and double carbon-carbon bonds in a benzene ring are termed:

- (A) Conjugate bonds
- (B) Coordinate covalent bonds
- (C) Fixed localized bonds
- (D) Ionic bonds

Q106. CHEM

Which of the following classes of hydrocarbons exhibits the highest relative acidity?

- (A) Alkane
- (B) Alkene
- (C) Alkyne
- (D) Cycloalkane

Q107. CHEM

In the photochemical free radical chlorination of methane, the attack of a chlorine free radical on a methane molecule to generate a methyl free radical occurs during the:

- (A) Initiation step
- (B) Propagation step
- (C) Termination step
- (D) Equilibrium step

Q108. CHEM

The ratio of sigma (σ) bonds to pi (π) bonds in a molecule of benzene (C_6H_6) is:

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

Q109. CHEM

When a halide ion is removed from an alkyl halide, a carbocation is formed. Identify the most reactive (least stable) carbocation:

- (A) Primary carbocation
- (B) Secondary carbocation
- (C) Tertiary carbocation
- (D) Methyl carbocation

Q110. CHEM

Freon is commercially and commonly utilized as a:

- (A) Refrigerant
- (B) Solvent
- (C) Insecticide
- (D) Fire extinguisher

Q111. CHEM

Neopentyl chloride belongs to which structural class of alkyl halides?

- (A) Primary alkyl halide
- (B) Secondary alkyl halide
- (C) Tertiary alkyl halide
- (D) Quaternary alkyl halide

Q112. CHEM

What is the common chemical name of propane-1,2,3-triol?

- (A) Butyl alcohol
- (B) Glycol
- (C) Glycerol
- (D) Propyl alcohol

Q113. CHEM

Benzene is produced when which of the following compounds is heated with a metallic reducing agent (such as zinc or sodium)?

- (A) Alcohol
- (B) Butyl alcohol
- (C) Propanol
- (D) Phenol

Q114. CHEM

When phenol reacts with formaldehyde in the presence of an acidic or basic catalyst, which intermediate product is initially formed?

- (A) Adduct (hydroxymethyl phenol)
- (B) Hydronium ion
- (C) Oxonium ion
- (D) Phenoxide ion

Q115. CHEM

What is the correct IUPAC name for the organic compound $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCH}_2\text{CHO}$?

- (A) 3-oxohexanal
- (B) 3-one hexanal
- (C) 2-oxohexanol
- (D) 3-one hexanol

Q116. CHEM

Which is the most suitable reagent for the selective oxidation of a primary alcohol to an aldehyde ($\text{R}-\text{CH}_2\text{OH} \rightarrow \text{R}-\text{CHO}$)?

- (A) $\text{KMnO}_4/\text{NaOH}$
- (B) Pyridinium chlorochromate (PCC)
- (C) $\text{CrO}_3/\text{H}_2\text{SO}_4$
- (D) $\text{K}_2\text{Cr}_2\text{O}_7/\text{conc. H}_2\text{SO}_4$

Q117. CHEM

Which one of the following qualitative diagnostic tests is also known as the silver mirror test?

- (A) Fehling's test
- (B) Iodoform test
- (C) Tollens' reagent test
- (D) Benedict's test

Q118. CHEM

Which among the following substituted carboxylic acids exhibits the lowest pH (highest acidity)?

- (A) $\text{CH}_3\text{CH}_2\text{COOH}$
- (B) $\text{CH}_2\text{ClCH}_2\text{COOH}$
- (C) $\text{CH}_3\text{CCl}_2\text{COOH}$
- (D) $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$

Q119. CHEM

If both a carboxylic acid group ($-\text{COOH}$) and a ketone group ($-\text{CO}-$) are present in the same carbon chain, the systematic IUPAC name is formed using:

- (A) oxo, oic acid
- (B) one, oic acid
- (C) al, oic acid
- (D) ol, oic acid

Q120. CHEM

When monocarboxylic acids and dicarboxylic acids of comparable molecular mass are compared, how do their melting points compare?

- (A) Monocarboxylic acids have greater melting points
- (B) Dicarboxylic acids have greater melting points
- (C) Both acids have similar melting points
- (D) No consistent trend exists

Q121. CHEM

When ingested food enters the stomach, the catalytic action of which enzyme ceases due to the highly acidic gastric pH?

- (A) Lipase
- (B) Amylase
- (C) Maltase
- (D) Hydrolase

Q122. CHEM

Which of the following is a copper-containing plasma protein that plays an essential physiological role in binding and transporting copper throughout the body?

- (A) Hemoglobin
- (B) Glycoprotein
- (C) Ceruloplasmin
- (D) Histone

PHY SECTION: PHYSICS

Questions 123 to 176 (54 MCQs)

Q123. PHY

Which of the following mathematical equations correctly relates the peak voltage (V_0) and root-mean-square voltage (V_{rms}) of an alternating sinusoidal voltage?

- (A) $V_0 = 1.414 V_{\text{rms}}$
- (B) $V_0 = 10.10 V_{\text{rms}}$
- (C) $V_0 = 10.70 V_{\text{rms}}$
- (D) Both A and B

Q124. PHY

What is the shape of the velocity-time graph for an object moving along a straight line with uniform (constant) acceleration?

- (A) Parabolic line
- (B) Straight line with a constant slope
- (C) Incline curve
- (D) Decline curve

Q125. PHY

Which of the following provides the correct physical definition of variable velocity?

- (A) Unequal distances are covered in equal intervals of time
- (B) Equal displacements are made in unequal intervals of time
- (C) Unequal displacements are made in equal intervals of time
- (D) Equal displacements are made in equal intervals of time

Q126. PHY

A stone projected horizontally from the roof of a tall building follows a trajectory whose geometric path is:

- (A) Circular
- (B) Two straight line segments
- (C) Hyperbolic
- (D) Parabolic

Q127. PHY

Which of the following statements regarding Newton's third law of motion is INCORRECT?

- (A) The reaction force on a body is always balanced by the action force on the body
- (B) Reaction and action forces are always equal in magnitude
- (C) Action and reaction forces never act on the same body
- (D) Newton's third law is valid in all mechanical interactions

Q128. PHY

A fireman of mass m slides down a vertical rope. The breaking tension of the rope is $\frac{3}{4}$ of his total weight. With what minimum acceleration must the fireman slide down so that the rope does not snap?

- (A) g
- (B) $\frac{g}{4}$
- (C) $\frac{3g}{4}$
- (D) 0

Q129. PHY

When a heavy coin falls through a short distance in air, it does not reach terminal velocity primarily because:

- (A) The coin has not hit the ground yet
- (B) The weight of the coin is equal to air resistance
- (C) The weight of the coin increases as air resistance increases
- (D) The weight of the coin remains substantially greater than the air drag force

Q130. PHY

The electrical energy consumed by a 60 W light bulb in 2 s is:

- (A) 120 J
- (B) 60 J
- (C) 30 J
- (D) 0.02 J

Q131. PHY

An elastic spring stretched by a displacement x stores potential energy V . If the stretching is increased to nx , the potential energy stored in the spring becomes:

- (A) nV
- (B) $\frac{V}{n}$
- (C) n^2V
- (D) $\frac{V}{n^2}$

Q132. PHY

Assuming negligible energy loss due to friction and air resistance, a pole vaulter converts kinetic energy directly into gravitational potential energy. If an athlete lifts his center of gravity by 5.0 m during a vault, what minimum horizontal running speed must he possess upon planting the pole? (Take $g = 10 \text{ m/s}^2$)

- (A) 5.0 m/s
- (B) 10.0 m/s
- (C) 15.0 m/s
- (D) 20.0 m/s

Q133. PHY

A particle of mass m initially at rest is acted upon by a constant force P for a time interval t . The kinetic energy acquired by the particle is:

- (A) $\frac{P^2 t^2}{m}$
- (B) $\frac{P^2 t^2}{2m}$
- (C) $\frac{P^2 t^2}{3m}$
- (D) $\frac{P^2 t^2}{4m}$

Q134. PHY

The number of complete revolutions contained in an angular displacement of 3π radians is:

- (A) $\frac{1}{60}$
- (B) $\frac{3}{2}$
- (C) 2
- (D) 6

Q135. PHY

If a heavy flywheel rotates with a constant angular velocity of 3.0 rad/s , the time period required to complete one revolution is approximately:

- (A) 0.67 s
- (B) 1.0 s
- (C) 1.3 s
- (D) 2.1 s

Q136. PHY

An aircraft performs a vertical loop of radius r . The minimum speed required at the highest point of the loop to maintain a circular path without falling is:

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

Q137. PHY

Which of the following characteristics of a sound wave increases directly when its amplitude is increased?

- (A) Wavelength
- (B) Frequency
- (C) Pitch
- (D) Loudness

Q138. PHY

An aircraft travels at a speed of $0.50 v$, where v is the speed of sound. If the aircraft approaches a stationary observer while emitting a sound of frequency 200 Hz, what frequency is detected by the observer?

- (A) 400 Hz
- (B) 100 Hz
- (C) 120 Hz
- (D) 180 Hz

Q139. PHY

If the spectral absorption lines in the light arriving from a distant galaxy are shifted toward the red end of the spectrum, it indicates that the galaxy is:

- (A) Approaching the Earth
- (B) Receding from the Earth
- (C) Stationary relative to the Earth
- (D) Moving in a perpendicular circular orbit

Q140. PHY

The shortest linear distance between any two adjacent points vibrating in phase on a progressive wave is called the:

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

Q141. PHY

In the complete absence of external damping and resistive frictional forces, when will an oscillating simple harmonic system cease oscillating?

- (A) Never
- (B) After 10 minutes
- (C) In 10 minutes
- (D) Immediately

Q142. PHY

Mechanical waves can be generated and transmitted through all of the following EXCEPT:

- (A) Oscillating electric and magnetic fields
- (B) Helical coil springs
- (C) Stretched ropes
- (D) Surface water waves

Q143. PHY

Reducing the suspended mass M of a simple harmonic mass-spring oscillator to $\frac{M}{4}$ will change its natural frequency of oscillation by a factor of:

- (A) One-fourth
- (B) Double
- (C) Quadruple
- (D) Half

Q144. PHY

A distant star recedes radially from Earth with a velocity of 1.40×10^7 m/s. It emits a characteristic spectral line of frequency 4.57×10^{14} Hz. Taking the speed of light as $c = 3.00 \times 10^8$ m/s, what is the observed frequency detected on Earth?

- (A) 2.04×10^{13} Hz
- (B) 4.36×10^{14} Hz
- (C) 4.57×10^{14} Hz
- (D) 4.79×10^{14} Hz

Q145. PHY

Thermodynamics is the branch of physics that primarily investigates the quantitative relationships between:

- (A) Heat energy and mechanical work
- (B) Heat and ionization energies
- (C) Chemical and mechanical energies
- (D) Kinetic and gravitational potential energies

Q146. PHY

When an ideal gas undergoes an isothermal compression process, the product of its pressure and volume (PV) during the process:

- (A) Continuously increases
- (B) Remains constant
- (C) Decreases to zero
- (D) Fluctuates periodically

Q147. PHY

The temperature of a fixed mass of an ideal gas is raised from 150°C to 300°C during an isobaric process. The final volume of the gas will be:

- (A) Halved
- (B) Doubled
- (C) Unchanged
- (D) Less than double

Q148. PHY

A capacitor of capacitance C is charged by a battery until its stored electrical potential energy is U . After disconnecting the battery, an identical uncharged capacitor of capacitance C is connected in parallel with it. The electrical energy stored in each individual capacitor is now:

- (A) $\frac{U}{2}$
- (B) $\frac{U}{4}$
- (C) $4U$
- (D) $2U$

Q149. PHY

What is the electric potential difference between two points in an electrostatic field if 600 J of work is required to move a positive charge of 2.0 C between them?

- (A) 1200 V
- (B) 800 V
- (C) 300 V
- (D) 0 V

Q150. PHY

Gauss's law cannot be employed directly to determine which of the following physical quantities?

- (A) Electric field intensity
- (B) Electric flux density
- (C) Enclosed electric charge
- (D) Absolute permittivity of free space

Q151. PHY

Which one of the following statements is true regarding fundamental forces in nature?

- (A) Electrostatic force obeys the inverse square law while gravitational force does not
- (B) Both gravitational force and electrostatic force are purely repulsive in nature
- (C) Gravitational force is much weaker than electrostatic force
- (D) Neither electrostatic force nor gravitational force obeys the inverse square law

Q152. PHY

The value of Coulomb's constant k in electrostatics depends upon:

- (A) The nature of the medium only
- (B) The system of units only
- (C) The magnitude and sign of the charges
- (D) The nature of the medium and the system of units

Q153. PHY

A charged particle moves in a uniform electric field. For the resulting motion of the particle due to the field, which physical quantity has a constant non-zero value?

- (A) Acceleration
- (B) Displacement
- (C) Rate of change of acceleration
- (D) Velocity

Q154. PHY

A capacitor of capacitance C carries a charge Q and stores energy W . If the charge stored on the plates is increased to $2Q$, the stored energy becomes:

- (A) $\frac{W}{4}$
- (B) $\frac{W}{2}$
- (C) $2W$
- (D) $4W$

Q155. PHY

What is the electrical potential difference across an ideal closed switch in an operating circuit?

- (A) 0 V
- (B) 1 V
- (C) 2 V
- (D) 3 V

Q156. PHY

A 3.0 V battery is connected in series with an ideal ammeter and a $2.0\ \Omega$ resistor. What is the reading indicated on the ammeter?

- (A) 1.0 A
- (B) 1.5 A
- (C) 5.0 A
- (D) 6.0 A

Q157. PHY

The electrical resistance of an ohmic metallic conductor does NOT depend directly on which of the following?

- (A) Cross-sectional area
- (B) Resistivity
- (C) Length
- (D) Mass

Q158. PHY

Which of the following statements is NOT correct concerning Kirchhoff's rules?

- (A) Kirchhoff's current rule is based on the law of conservation of charge
- (B) A Wheatstone bridge circuit is an application of Kirchhoff's rules
- (C) Kirchhoff's rules are more suitable for AC circuits than DC circuits
- (D) Kirchhoff's voltage rule is based on the law of conservation of energy

Q159. PHY

Materials whose electrical resistance decreases with an increase in temperature possess a:

- (A) High positive temperature coefficient
- (B) Negative temperature coefficient
- (C) Positive temperature coefficient
- (D) Zero temperature coefficient

Q160. PHY

A low-voltage power supply with an electromotive force (e.m.f.) of 20.0 V and an internal resistance of $1.5\ \Omega$ delivers electrical power to an aquarium heater of resistance $6.5\ \Omega$. What is the power supplied to the heater?

- (A) 41 W
- (B) 50 W
- (C) 53 W
- (D) 62 W

Q161. PHY

Electric forces can change both the magnitude and direction of a charged particle's velocity, whereas magnetic forces can change:

- (A) Only the magnitude of velocity
- (B) Only the direction of velocity
- (C) Both the magnitude and direction of velocity
- (D) Neither the magnitude nor direction of velocity

Q162. PHY

Which plane surface experiences the greatest magnetic flux when placed in the same uniform magnetic field at the same orientation, given that each has a surface area of $1.0\ \text{m}^2$?

- (A) Circular surface
- (B) Rectangular surface
- (C) Square surface
- (D) Magnetic flux is independent of the geometric shape

Q163. PHY

The fundamental source of an external magnetic field is a:

- (A) Isolated magnetic monopole
- (B) Static electric charge
- (C) Non-magnetic substance
- (D) Current loop

Q164. PHY

A copper rod of length 1.0 m moves perpendicularly with a speed of 20 m/s through a uniform magnetic field of strength 0.6 T. What is the magnitude of the motional e.m.f. induced across its ends?

- (A) 10 V
- (B) 12 V
- (C) 14 V
- (D) 16 V

Q165. PHY

In SI base and derived units, the rate of change of magnetic flux ($\Delta\Phi/\Delta t$) can be expressed as:

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

Q166. PHY

The electrodynamic suspension and stabilization mechanism of a magnetic levitation (maglev) train operates fundamentally in accordance with:

- (A) Faraday's law
- (B) Planck's quantum law
- (C) Ohm's law
- (D) Lenz's law

Q167. PHY

A circular copper hoop is held in a vertical east–west plane in a uniform magnetic field whose field lines run horizontally in the north–south direction. The largest induced e.m.f. is generated when the hoop is:

- (A) Rotated about a north–south axis
- (B) Rotated about an east–west axis
- (C) Translated rapidly toward the east without rotation
- (D) Translated rapidly toward the south without rotation

Q168. PHY

In an ideal electrical transformer, there is no _____ connection between the primary and secondary coils, but they are linked _____:

- (A) Magnetic, electrically
- (B) Electrical, magnetically
- (C) Magnetic, magnetically
- (D) Electrical, optically

Q169. PHY

When the temperature of an intrinsic semiconductor is reduced to absolute zero (0 K), the semiconductor behaves as a/an:

- (A) Conductor
- (B) Semiconductor
- (C) Superconductor
- (D) Insulator

Q170. PHY

If an electron, a proton, a neutron, and an alpha particle all move with the same velocity, which particle has the shortest de Broglie wavelength?

- (A) Electron
- (B) Proton
- (C) Neutron
- (D) Alpha particle

Q171. PHY

The emission of electrons from a clean photosensitive metal surface upon the absorption of electromagnetic radiation is known as the:

- (A) Compton effect
- (B) Photoelectric effect
- (C) Pair production
- (D) Black body radiation

Q172. PHY

In a photoelectric effect experiment, the stopping potential is defined as:

- (A) The kinetic energy of the fastest ejected electron
- (B) The potential energy of the fastest ejected electron
- (C) The incident photon energy
- (D) The retarding electric potential that causes the photoelectric current to drop to zero

Q173. PHY

The complete atomic emission line spectrum of hydrogen contains discrete series of spectral lines spanning which electromagnetic regions?

- (A) Ultraviolet region only
- (B) Infrared region only
- (C) Visible region only
- (D) All of these regions

Q174. PHY

According to Bohr's atomic model, the orbital speed of an electron in the first orbit ($n = 1$) of a hydrogen atom is approximately:

- Ⓐ $2.19 \times 10^6 \text{ m/s}$
 - Ⓑ $2.19 \times 10^{-6} \text{ m/s}$
 - Ⓒ $2.19 \times 10^4 \text{ m/s}$
 - Ⓓ $2.19 \times 10^{-4} \text{ m/s}$
-

Q175. PHY

A low-energy neutron radiation field has a relative biological effectiveness (RBE) factor of 10. What total energy is absorbed by a human body of mass 80 kg if the equivalent biological dose received is 400 rem?

- Ⓐ 16 J
 - Ⓑ 32 J
 - Ⓒ 48 J
 - Ⓓ 64 J
-

Q176. PHY

Thorium-234 (${}_{90}^{234}\text{Th}$) decays into Protactinium-234 (${}_{91}^{234}\text{Pa}$) via the emission of which subatomic particle?

- Ⓐ Alpha particle
 - Ⓑ Beta particle
 - Ⓒ Gamma photon
 - Ⓓ Positron
-

ENG SECTION: ENGLISH

Questions 177 to 194 (18 MCQs)

Q177. ENG

The radioactive isotope Strontium-87 has a half-life of 8.70 hours. What is its radioactive decay constant λ ?

- (A) 0.000022 s
- (B) 45000 s⁻¹
- (C) 0.000022 s⁻¹
- (D) 0.000032 s⁻¹

Q178. ENG

The synonym of the word 'Capricious' is:

- (A) Fickle
- (B) Predictable
- (C) Uniform
- (D) Invariable

Q179. ENG

Which of the following words will fill in the blank most appropriately?

Diseases like diabetes are supposed to be taken seriously or they can be _____.

- (A) Cursing
- (B) Healthy
- (C) Fatal
- (D) Impersonating

Q180. ENG

Choose the most appropriate antonym for the word 'abandonment':

- (A) Cessation
- (B) Stoppage
- (C) Halt
- (D) Extension

Q181. ENG

Fill in the blank with the correct verb form:

The shepherd ploughed this mountain with cattle the first time it _____ ever ploughed.

- (A) was
- (B) was been
- (C) had
- (D) had been

Q182. ENG

Fill in the blank with the appropriate verb:

To give one some idea of rabies' horrors, one _____ only read such descriptions as the following: spasms, restlessness, shudders at the least breath of air, an ardent thirst, convulsive movements, and fits of furious rage.

- (A) Needs
- (B) Need
- (C) Needed
- (D) Has needed

Q183. ENG

Fill in the blank with the correct verbal phrase:

By 2030, people _____ been reading the works of Charles Dickens for more than 190 years.

- (A) Had
- (B) Will
- (C) Have
- (D) Will have

Q184. ENG

Choose the most suitable and grammatically correct sentence out of the following:

- (A) Penny did not let me to get my book.
- (B) Penny was not leaving me to get my book.
- (C) Penny did not let me get my book.
- (D) Penny had not left me get my book.

Q185. ENG

Which of the following sentences is correctly punctuated and grammatically sound?

- (A) I want to live near my parents live
- (B) I want to live where my parents live
- (C) I want to live where, my parents live
- (D) I want to live where: my parents live

Q186. ENG

Choose the sentence displaying the correct use of definite and indefinite articles:

- (A) Natasha can play a piano and a violin.
- (B) Natasha can play the piano and the violin.
- (C) Natasha can play the piano and a violin.
- (D) Natasha can play piano and violin.

Q187. ENG

Choose the correct preposition to fill in the blank:

Distribute the handouts _____ the candidates.

- (A) into
- (B) among
- (C) in
- (D) on

Q188. ENG

Choose the sentence that correctly employs commas and articles in a serial list:

- (A) Samar bought an apple, an orange and an pear.
- (B) Samar bought an apple a orange and a pear.
- (C) Samar bought an apple, an orange, and a pear.
- (D) Samar bought a apple, an orange and a pear.

Q189. ENG

Identify the sentence that is completely error-free:

- (A) I do not enjoy being laughed at by other people.
- (B) I did not enjoy laughing by other people.
- (C) I am not enjoying laughing by other people.
- (D) I do not enjoying being laughed at other people.

Q190. ENG

Choose the sentence that is grammatically correct:

- (A) We agreed that the play was rather boring so we felt bored.
- (B) We agreed that the play was rather bored so we felt boring.
- (C) We agreed that the play was rather bore so we felt bores.
- (D) We agreed that the play was rather bores so we felt bored.

Q191. ENG

Select the most appropriate contextual word to fill in the blank:

I decided to sell the piece of land when I was offered a more _____ price.

- (A) True
- (B) Realistic
- (C) Exact
- (D) Perfect

Q192. ENG

The idiom 'To cut off the head' means:

- (A) Defrock
- (B) Decapitate
- (C) Impale
- (D) Urbanite

Q193. ENG

Fill in the blank with the correct response:

Wasim was so good at Mathematics that people considered him to be a _____.

- (A) Prodigy
- (B) Produgal
- (C) Primeval
- (D) Profligate

Q194. ENG

Fill in the blank with the appropriate verb form:

The newly elected president and CEO for the newly established branch of our company _____ arrived recently.

- (A) Have
- (B) Having
- (C) Have been
- (D) Has

LOGIC SECTION: LOGICAL REASONING

Questions 195 to 200 (6 MCQs)

Q195. LOGIC

Read the passage and the statements below. Choose the correct deduction basing your answer strictly on the text provided.

'Queen Elizabeth II's Platinum Jubilee, celebrating her 70 years on the British throne, was above all a tribute to one of history's great acts of constancy. Her reign spanned virtually the entire post-World War II era, making her a witness to cultural upheavals from the Beatles to Brexit.'

STATEMENTS:

- I. There has been another queen of the British throne named Elizabeth before her.
- II. Brexit is a normal occurrence.
- III. Elizabeth was Queen of the British during World War II.

- (A) I, II, and III are all correct
- (B) Only III is correct
- (C) Only I is correct
- (D) Only I and III are correct

Q196. LOGIC

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

CAB, FAE, IAH, _____

- (A) JHK
- (B) LAK
- (C) JGK
- (D) IGJ

Q197. LOGIC

Read the following premises and determine the correct answer:

Drake was wearing a blue shirt with black jeans and brown shoes. John was wearing a red shirt with black jeans and black shoes. Ahmad was wearing black jeans, a blue or red shirt, and shoes that were not black. Who copied Drake's attire?

- (A) Ahmad
- (B) John
- (C) Drake
- (D) Cannot be determined from the given information

Q198. LOGIC

Consider the following premises to be true:

- 1. Some bags are pouches.
- 2. All pouches are cases.
- 3. No cases are purses.

Which of the following conclusions is/are **NECESSARILY TRUE**?

- I. Some pouches are purses.
- II. Some bags are cases.
- III. No bags are purses.

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

Q199. LOGIC

Read the statement, assuming everything in it to be true. Decide which of the suggested courses of action logically follows and is worth pursuing.

Statement: 'Aalia wants to sleep but cannot do so due to regular noise in and around her house every day.'

Courses of Action:

- I. Insert good quality noise blockers into her ears.
- II. Take strong sleeping pills.

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

Q200. LOGIC

Evaluate the relationship between the two statements below:

Statement I: The literacy rate in the district has been steadily increasing.

Statement II: The district administration has conducted an extensive training program for the workers involved in the literacy drive.

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

OFFICIAL VERIFIED ANSWER KEY

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

SUBJECT-WISE PERFORMANCE BREAKDOWN

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

PMDC PROVINCIAL MERIT FORMULA

Official Weightage Law:

- MDCAT Component (50%): (Your Score / 200) × 50
- FSc / HSSC Component (40%): (FSc Marks / 1100) × 40
- Matric / SSC Component (10%): (Matric Marks / 1100) × 10

Estimated Provincial Merit Aggregate: ----- %

PROPOLIS COGNITIVE ERROR AUTOPSIES

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

Question #1 Key: (A)

BIOLOGY
05. Acellular Life

What does the term bacteriophage refer to?

CORE CONCEPT & DERIVATION

Bacteriophages are obligate intracellular viral parasites that selectively target, infect, and replicate within bacterial hosts.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Bacteriophages consist of a nucleic acid genome encapsulated in a protein capsid.
- They attach to specific receptors on bacterial cell walls, inject their genetic material, and utilize bacterial machinery to produce viral progeny.

Why other options are incorrect:

- **Option B:** Bacteria do not infect viruses; viruses are acellular obligate intracellular parasites.
- **Option C:** Viruses lack metabolic machinery and cannot behave as bacteria.
- **Option D:** A virion is an individual viral particle, not a hybrid combination with a bacterium.

Question #3 Key: (C)

BIOLOGY
05. Acellular Life

How many tail fibrils are attached to the end plate of a bacteriophage?

CORE CONCEPT & DERIVATION

The hexagonal base plate of a T-even bacteriophage anchors specific protein tail fibers required for host surface landing.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The base plate of a T4 bacteriophage exhibits six-fold rotational symmetry.
- Exactly six long tail fibers (fibrils) extend from the base plate to bind host cell lipopolysaccharides.

Why other options are incorrect:

- **Option A:** Two tail fibrils do not satisfy the six-fold symmetry of the T4 base plate.
- **Option B:** Four tail fibrils are structurally incorrect for T-even phages.
- **Option D:** Eight tail fibrils exceed the morphological complement of the base plate.

Question #2 Key: (C)

BIOLOGY
05. Acellular Life

Which of the following viruses contains single-stranded DNA?

CORE CONCEPT & DERIVATION

Animal viruses possess either DNA or RNA genomes that can be double-stranded or single-stranded; parvoviruses are characterized by a single-stranded DNA genome.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Parvoviruses are among the smallest known non-enveloped icosahedral DNA viruses.
- They contain a linear single-stranded DNA genome of approximately 5 kilobases.

Why other options are incorrect:

- **Option A:** Adenoviruses contain non-enveloped, linear, double-stranded DNA.
- **Option B:** Herpesviruses possess large, enveloped, linear, double-stranded DNA genomes.
- **Option D:** Poxviruses contain complex, enveloped, linear, double-stranded DNA.

Question #4 Key: (D)

BIOLOGY
05. Acellular Life

The enzymes integrase, protease, and reverse transcriptase are found in which virus?

CORE CONCEPT & DERIVATION

Retroviruses package specific viral enzymes within their capsids to convert their RNA genome into host-integrated DNA and mature their proteins.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Human immunodeficiency virus (HIV) is a lentivirus containing two positive-sense RNA strands.
- Its viral core carries reverse transcriptase (RNA-dependent DNA polymerase), integrase (for proviral chromosomal integration), and protease (for precursor polyprotein cleavage).

Why other options are incorrect:

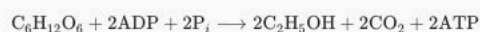
- **Option A:** Hepatitis A is a picornavirus lacking reverse transcriptase and integrase.
- **Option B:** Herpesvirus is a double-stranded DNA virus that replicates using DNA polymerase.
- **Option C:** Influenza virus uses an RNA-dependent RNA polymerase and lacks integrase.

Question #5 Key: (C)BIOLOGY
04. Bioenergetics

What is the end product of glucose by yeast in anaerobic respiration?

CORE CONCEPT & DERIVATION

Alcoholic fermentation in yeast converts pyruvate into ethanol and carbon dioxide under anoxic conditions to regenerate NAD^+ .

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

- Glycolysis breaks down glucose into two molecules of pyruvate.
- Pyruvate is decarboxylated by pyruvate decarboxylase to yield acetaldehyde and CO_2 .
- Acetaldehyde is subsequently reduced to ethanol by alcohol dehydrogenase.

Why other options are incorrect:

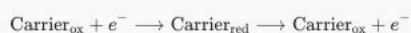
- Option A:** Molecular oxygen is neither produced nor consumed in anaerobic fermentation.
- Option B:** Water is a product of aerobic oxidative phosphorylation, not alcoholic fermentation.
- Option D:** Lactic acid fermentation occurs in lactic acid bacteria and muscle cells without CO_2 release.

Question #6 Key: (D)BIOLOGY
04. Bioenergetics

Each carrier in the electron transport chain is first _____ and then _____.

CORE CONCEPT & DERIVATION

Respiratory chain electron transport proceeds via sequential redox reactions where each protein complex accepts electrons before donating them downstream.

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

- A carrier in the oxidized state accepts an incoming electron, undergoing reduction.
- Upon passing the electron to the subsequent carrier with higher redox potential, it undergoes oxidation.

Why other options are incorrect:

- Option A:** Respiratory carriers are stable membrane protein complexes and do not undergo continuous degradation.
- Option B:** Protein complexes are constitutive structures, not newly generated during individual electron transfers.
- Option C:** A carrier must first accept an electron (reduction) before it can donate it (oxidation).

Question #7 Key: (D)BIOLOGY
04. Bioenergetics

The electron transport chain explains:

CORE CONCEPT & DERIVATION

Peter Mitchell's chemiosmotic hypothesis explains how the mitochondrial electron transport chain establishes a proton-motive force that drives ATP synthesis.

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

- Exergonic electron transfers pump protons from the matrix into the intermembrane space.
- The resulting electrochemical gradient directs protons back through F_0F_1 -ATP synthase, driving the phosphorylation of ADP.

Why other options are incorrect:

- Option A:** Photophosphorylation specifically describes light-driven ATP production in chloroplasts.
- Option B:** The Z-scheme represents non-cyclic electron transport in photosynthetic light reactions.
- Option C:** Photolysis is the photochemical cleavage of water at photosystem II.

Question #8 Key: (B)BIOLOGY
04. Bioenergetics

What is the color of the chlorophyll-b molecule?

CORE CONCEPT & DERIVATION

Chlorophyll-a and chlorophyll-b possess distinct porphyrin ring substituents that alter their light absorption spectra and visual coloration.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Chlorophyll-a has a methyl ($-\text{CH}_3$) group at carbon-3 and appears bright bluish-green.
- Chlorophyll-b possesses a formyl ($-\text{CHO}$) group at carbon-3 and appears yellowish-green.

Why other options are incorrect:

- Option A:** Bluish-green is the characteristic visual color of chlorophyll-a.
- Option C:** Dark green does not represent the precise chromatographic description of isolated chlorophyll-b.
- Option D:** Chlorophyll pigments do not appear reddish-green; phycoerythrin reflects red wavelengths.

Question #9 Key: (B)BIOLOGY
02. Biomolecules*Upon initial hydrolysis, starch yields:***CORE CONCEPT & DERIVATION**

Endoamylases cleave internal $\alpha(1 \rightarrow 4)$ glucosidic linkages of starch to produce disaccharide units prior to final monosaccharide cleavage.

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

- Initial enzymatic hydrolysis of starch by salivary or pancreatic amylase produces the disaccharide maltose.
- Maltose is subsequently hydrolyzed into two D-glucose molecules by maltase in the brush border.

Why other options are incorrect:

- Option A:** Free glucose is the terminal product formed after maltase acts on maltose.
- Option C:** Sucrose is a disaccharide of glucose and fructose, not a starch breakdown intermediate.
- Option D:** Mannose is a C-2 epimer of glucose absent in starch.

Question #10 Key: (A)BIOLOGY
02. Biomolecules*Human bone cells contain _____ % of water.***CORE CONCEPT & DERIVATION**

The water content of human tissues varies inversely with the degree of extracellular matrix mineralization.

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

- Soft tissues such as brain cells contain approximately 85% water by weight.
- Highly mineralized skeletal tissue contains roughly 20% water, with the remainder consisting of hydroxyapatite minerals and collagen fibers.

Why other options are incorrect:

- Option B:** 40% exceeds the physiological hydration level of human bone matrix.
- Option C:** 85% represents the water content of brain cells.
- Option D:** 90% is found in dilute physiological fluids like blood plasma.

Question #11 Key: (C)BIOLOGY
02. Biomolecules*The unique three-dimensional shape of the fully folded polypeptide constitutes the:***CORE CONCEPT & DERIVATION**

Protein structural hierarchy spans four levels; tertiary structure specifies the complete geometric conformation of a single polypeptide chain.

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

- Tertiary structure is stabilized by hydrophobic interactions, ionic bonds, hydrogen bonds, and covalent disulfide bridges between amino acid R-groups.
- This folding establishes the distinct, biologically active three-dimensional shape of a single polypeptide chain.

Why other options are incorrect:

- Option A:** Primary structure is the linear sequence of amino acids joined by peptide bonds.
- Option B:** Secondary structure refers to localized folding into α -helices or β -pleated sheets.
- Option D:** Quaternary structure describes the spatial assembly of multiple polypeptide subunits.

Question #12 Key: (C)BIOLOGY
02. Biomolecules*Butyric acid is a _____ carbon fatty acid.***CORE CONCEPT & DERIVATION**

Saturated fatty acids are unbranched carboxylic acids classified according to their total carbon atom count.

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

- Butyric acid (systematic IUPAC name: butanoic acid) is a four-carbon saturated carboxylic acid.
- It occurs naturally in butterfat and as an end product of intestinal microbial fermentation.

Why other options are incorrect:

- Option A:** A six-carbon saturated fatty acid is caproic acid (hexanoic acid).
- Option B:** A two-carbon carboxylic acid is acetic acid (ethanoic acid).
- Option D:** An eight-carbon saturated fatty acid is caprylic acid (octanoic acid).

Question #13 Key: (C)BIOLOGY
02. Biomolecules*Which of the following is a conjugated molecule?***CORE CONCEPT & DERIVATION**

Conjugated molecules are formed when two structurally distinct chemical classes of macromolecules unite via covalent bonds.

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

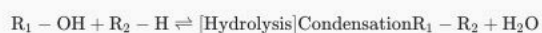
- Glycoproteins consist of carbohydrate oligosaccharide chains covalently linked to a polypeptide backbone.
- Because they combine carbohydrate and protein domains, they represent conjugated biomolecules.

Why other options are incorrect:

- Option A:** Unmodified proteins are simple biomolecules consisting purely of amino acid residues.
- Option B:** Simple lipids consist solely of glycerol esters and fatty acids.
- Option D:** Vitamins are organic micronutrients, not conjugated macromolecules.

Question #14 Key: (B)BIOLOGY
02. Biomolecules*The hydrolysis process is the reverse of which process?***CORE CONCEPT & DERIVATION**

Polymerization occurs through condensation with the removal of water, whereas depolymerization occurs via hydrolysis with the consumption of water.

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

- Condensation (dehydration synthesis) combines smaller subunits into a larger polymer while releasing a water molecule.
- Hydrolysis consumes a water molecule to cleave the covalent bond holding the polymer subunits together.

Why other options are incorrect:

- Option A:** Photolysis is chemical bond cleavage driven by photon absorption.
- Option C:** Deduction is a logical reasoning method.
- Option D:** Convection is a physical mode of bulk fluid heat transfer.

Question #15 Key: (C)BIOLOGY
01. Cell*Proteins are the main _____ of the cell.***CORE CONCEPT & DERIVATION**

In cellular biology, proteins provide the primary framework and physical architecture of membranes, organelles, and the cytoskeleton.

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

- Proteins constitute more than 50% of the dry weight of most cells.
- They form cellular membranes, microfilaments, intermediate filaments, and microtubules, establishing them as the main structural components of cells.

Why other options are incorrect:

- Option A:** Physiological components describes functional states rather than biochemical architectural material.
- Option B:** Functional components emphasizes enzymatic activity rather than anatomical composition.
- Option D:** Biological components is an overly general category encompassing all biomolecules.

Question #16 Key: (D)BIOLOGY
01. Cell*The cell wall may be absent in which of the following?***CORE CONCEPT & DERIVATION**

Certain prokaryotic groups within domains Bacteria and Archaea naturally lack rigid peptidoglycan or pseudopeptidoglycan cell walls.

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

- Among bacteria, members of the genus *Mycoplasma* completely lack cell walls and are bounded solely by sterol-stabilized membranes.
- Certain archaea (such as *Thermoplasma*) also lack cell walls entirely.

Why other options are incorrect:

- Option A:** Plants and algae universally possess cellulose-rich cell walls.
- Option B:** Fungi universally possess chitinous cell walls.
- Option C:** Fungi always possess cell walls consisting of chitin, glucans, and mannoproteins.

Question #17 Key: (B)BIOLOGY
01. Cell

_____ are the structures formed by invagination of the plasma membrane and have been associated...

CORE CONCEPT & DERIVATION

Mesosomes are folded invaginations of the bacterial plasma membrane that assist in cell wall synthesis, DNA replication, and binary fission.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Mesosomes form vesicular, tubular, or lamellar membrane intrusions into bacterial cytoplasm.
- They attach to bacterial chromosomes to aid in the segregation of replicated DNA into daughter cells during binary fission.

Why other options are incorrect:

- **Option A:** Lysosomes are eukaryotic digestive organelles containing acid hydrolases.
- **Option C:** Golgi bodies are eukaryotic endomembrane organelles for protein processing.
- **Option D:** Phragmoplasts are plant-specific cytoskeletal scaffolds that coordinate cell plate formation.

Question #18 Key: (C)BIOLOGY
01. Cell

Which of the following are single-membranous organelles?

CORE CONCEPT & DERIVATION

Cellular organelles are organized into non-membranous, single-membranous, or double-membranous compartments.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The endoplasmic reticulum, Golgi apparatus, and lysosomes are bound by a single phospholipid bilayer membrane.
- They form a functional interconnected unit termed the endomembrane system.

Why other options are incorrect:

- **Option A:** Mitochondria possess two membranes; ribosomes are non-membranous complexes.
- **Option B:** Cytosol is fluid cytoplasm, mitochondria are double-membranous, and ribosomes lack membranes.
- **Option D:** Mitochondria have outer and inner phospholipid bilayer membranes.

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

Movement of molecules against the concentration gradient is termed:

CORE CONCEPT & DERIVATION

Uphill transport of chemical species against an established concentration gradient requires metabolic energy input.

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

- Active transport uses integral carrier proteins (pumps) to move solutes from regions of low concentration to high concentration.
- This process directly hydrolyzes ATP (primary active transport) or couples to an ion gradient (secondary active transport).

Why other options are incorrect:

- **Option A:** Passive transport moves solutes down a concentration gradient without cellular energy expenditure.
- **Option C:** Facilitated diffusion is passive transport mediated by carrier or channel proteins.
- **Option D:** Filtration relies on hydrostatic pressure gradients across membrane pores.

Question #20 Key: (C)BIOLOGY
01. Cell

The digestive vacuoles and autophagosomes are also known as:

CORE CONCEPT & DERIVATION

Secondary lysosomes are hybrid digestive vesicles formed by the fusion of primary lysosomes with incoming endocytic or autophagic vacuoles.

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

- Primary lysosomes bud from the trans-Golgi network containing inactive acid hydrolases.
- Upon fusion with a phagosome (forming a digestive vacuole) or an autophagosome, it becomes a secondary lysosome where digestion proceeds.

Why other options are incorrect:

- **Option A:** Phagocytic vesicles are precursors prior to fusion with lysosomal hydrolases.
- **Option B:** Primary lysosomes are newly formed storage vesicles that have not yet engaged in digestion.
- **Option D:** Peroxisomes are metabolic organelles involved in fatty acid β -oxidation and peroxide detoxification.

Question #21 Key: (B)BIOLOGY
01. Cell*The cell wall of bacteria is composed of:***CORE CONCEPT & DERIVATION**

The eubacterial cell wall is composed of peptidoglycan, a cross-linked amino sugar polymer historically designated as murein.

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

- Murein consists of glycan chains containing alternating $\beta(1 \rightarrow 4)$ -linked N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM).
- These glycan strands are cross-linked by short peptide chains attached to NAM residues, conferring tensile strength against osmotic lysis.

Why other options are incorrect:

- **Option A:** Chitin is a homopolymer of N-acetylglucosamine found in fungal cell walls and arthropod exoskeletons.
- **Option C:** Cellulose is a polymer of $\beta(1 \rightarrow 4)$ -D-glucose found in plant and algal cell walls.
- **Option D:** Hemicellulose is a branched heteropolymer present in plant cell walls.

Question #22 Key: (B)BIOLOGY
01. Cell*Which one of the following is common to both prokaryotic and eukaryotic cells?***CORE CONCEPT & DERIVATION**

Ribosomes are universal ribonucleoprotein assemblies required for messenger RNA translation in all cellular organisms.

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

- Ribosomes occur in both prokaryotes (as 70S particles composed of 50S and 30S subunits) and eukaryotes (as 80S cytosolic particles composed of 60S and 40S subunits).
- They lack a lipid membrane and are essential for cellular protein synthesis across all domains of life.

Why other options are incorrect:

- **Option A:** Cytoplasmic streaming (cyclosis) requires an actin-myosin cytoskeleton found in eukaryotes.
- **Option C:** Binary fission is characteristic of prokaryotes; eukaryotic somatic cells divide by mitosis.
- **Option D:** A membrane-bound nuclear envelope is absent in prokaryotes.

Question #23 Key: (C)BIOLOGY
12. Nervous Coordination*There is no clear morphological difference between dendrites and axons in sensory neurons, except...***CORE CONCEPT & DERIVATION**

In pseudounipolar sensory neurons, peripheral and central branches share structural characteristics of axons, differing primarily at their specialized terminal endings.

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

- The peripheral process of a sensory neuron functions like a dendrite but possesses the histological diameter and myelination of an axon.
- Morphological distinction is clear only at the terminal portions: the peripheral end terminates in sensory receptors, while the central end forms presynaptic arborizations in the CNS.

Why other options are incorrect:

- **Option A:** Both peripheral and central branches maintain similar axonal thickness.
- **Option B:** Both processes can span extended lengths (up to one meter from periphery to spinal cord).
- **Option D:** Both branches can be heavily myelinated by Schwann cells or oligodendrocytes.

Question #24 Key: (A)BIOLOGY
12. Nervous Coordination*The neurotransmitter active outside the Central Nervous System (CNS) is:***CORE CONCEPT & DERIVATION**

Acetylcholine serves as the primary neurotransmitter of the peripheral nervous system, operating at neuromuscular junctions and autonomic synapses.

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

- In the peripheral nervous system, acetylcholine is released at all somatic neuromuscular junctions.
- It also acts at all preganglionic autonomic terminals and postganglionic parasympathetic nerve endings.

Why other options are incorrect:

- **Option B:** Dopamine functions predominantly in central neural circuits governing movement and reward.
- **Option C:** Glutamate is the principal excitatory neurotransmitter confined to the central nervous system.
- **Option D:** Serotonin acts mainly in the brainstem and enteric nervous system, not at peripheral somatic junctions.

Question #25 Key: (B)BIOLOGY
13. Chemical Coordination

A hormone that plays a major role in social bonding, childbirth, milk ejection, and sexual repr...

CORE CONCEPT & DERIVATION

Oxytocin is a hypothalamic nonapeptide stored in the posterior pituitary that stimulates smooth muscle contractions during birth and nursing while modulating bonding behaviors.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Oxytocin stimulates forceful myometrial contractions during labor via positive feedback (Ferguson reflex).
- It contracts mammary myoepithelial cells to trigger milk ejection (milk letdown) and promotes maternal-infant pair bonding.

Why other options are incorrect:

- **Option A:** Estrogen regulates female secondary sexual characteristics and endometrial proliferation.
- **Option C:** Prolactin stimulates milk synthesis within alveolar epithelial cells, not acute milk ejection.
- **Option D:** Secretin stimulates pancreatic bicarbonate secretion in the gastrointestinal tract.

Question #26 Key: (C)BIOLOGY
14. Reproduction

Which hormone is produced by the human placenta?

CORE CONCEPT & DERIVATION

During pregnancy, the syncytiotrophoblast of the placenta takes over the endocrine synthesis of steroid hormones required to maintain the uterine lining.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Following the luteal-placental shift around the 8th week of gestation, the placenta becomes the primary producer of progesterone.
- Placental progesterone maintains the secretory endometrium and suppresses myometrial contractility throughout pregnancy.

Why other options are incorrect:

- **Option A:** FSH is a glycoprotein gonadotropin secreted by the anterior pituitary.
- **Option B:** LH is secreted by the anterior pituitary gland to stimulate ovulation.
- **Option D:** Testosterone is produced primarily by the Leydig cells of the testes.

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

The middle layer of the meninges is the:

CORE CONCEPT & DERIVATION

The central nervous system is enveloped by three protective meningeal membranes: the outer dura mater, middle arachnoid mater, and inner pia mater.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The arachnoid mater is the avascular intermediate meningeal layer.
- It is separated from the pia mater by the subarachnoid space, which contains cerebrospinal fluid (CSF) and spiderweb-like trabeculae.

Why other options are incorrect:

- **Option B:** Pia mater is the delicate, vascularized innermost layer adhering to the surface of neural tissue.
- **Option C:** Dura mater is the dense, fibrous, outermost meningeal layer.
- **Option D:** The cranium is the bony skeletal vault enclosing the brain.

Question #28 Key: (B)BIOLOGY
12. Nervous Coordination

The part of the brain that guides smooth and accurate motions and maintains body posture is the...

CORE CONCEPT & DERIVATION

The cerebellum integrates sensory inputs from proprioceptors and the vestibular system to coordinate motor commands and maintain equilibrium.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The cerebellum compares intended motor signals from the motor cortex with actual somatic movement feedback.
- It calculates corrective signals to ensure precision, timing, smooth muscular coordination, and balance.

Why other options are incorrect:

- **Option A:** The cerebrum initiates voluntary movements and governs conscious cognition and sensory interpretation.
- **Option C:** The pons serves as a relay bridge between the cortex and cerebellum and contains respiratory centers.
- **Option D:** The medulla oblongata regulates cardiovascular, vasomotor, and respiratory reflex centers.

Question #29 Key: (C)BIOLOGY
07. Circulation / Transport

A water vascular system (ambulacral system) is a unique and complex organ system found specific...

CORE CONCEPT & DERIVATION

Phylum Echinodermata is defined by a coelom-derived hydraulic system that powers tube feet for locomotion, feeding, and gas exchange.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The ambulacral system consists of the madreporite, stone canal, ring canal, radial canals, and muscular ampullae.
- Hydrostatic pressure changes within this hydraulic circuit extend and retract the tube feet (podia) during locomotion and predation.

Why other options are incorrect:

- **Option A:** Sponges possess a water canal system lined by choanocytes, which is distinct from an ambulacral system.
- **Option B:** Arthropods possess an open circulatory system and jointed appendages.
- **Option D:** Fishes possess a closed cardiovascular system and a lateral line system.

Question #30 Key: (C)BIOLOGY
06. Digestion/Nutrition

Roundworms belong to which phylum?

CORE CONCEPT & DERIVATION

Nematodes are bilaterally symmetrical, unsegmented vermiform invertebrates characterized by a pseudocoelom and a collagenous cuticle.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Roundworms have cylindrical, unsegmented bodies with tapered ends, placing them in phylum Nematoda (Aschelminthes).
- They possess a complete digestive tract with separate mouth and anus within a fluid-filled pseudocoelom.

Why other options are incorrect:

- **Option A:** Annelida comprises segmented true coelomates such as earthworms and leeches.
- **Option B:** Coelenterata (Cnidaria) contains radially symmetrical diploblastic organisms.
- **Option D:** Platyhelminthes contains dorsoventrally flattened acoelomate flatworms.

Question #31 Key: (A)BIOLOGY
16. Evolution

A silverfish is classified as a/an:

CORE CONCEPT & DERIVATION

Common names of organisms can be misleading; anatomical morphology determines appropriate taxonomic placement.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Silverfish (Lepisma saccharina) are wingless (apterygote) terrestrial arthropods.
- They possess three body tagmata (head, thorax, abdomen), three pairs of walking legs, and segmented antennae, placing them in class Insecta.

Why other options are incorrect:

- **Option B:** Molluscs are soft-bodied, unsegmented invertebrates with a muscular foot, mantle, and radula.
- **Option C:** Jawless fishes (Agnatha) are primitive vertebrates such as lampreys and hagfishes.
- **Option D:** Cartilaginous fishes (Chondrichthyes) are aquatic vertebrates such as sharks and rays.

Question #32 Key: (B)BIOLOGY
08. Immunity

True tissues are absent in which of the following animal groups?

CORE CONCEPT & DERIVATION

Animals are divided into Parazoa (lacking true tissues) and Eumetazoa (possessing true organized germ layers and tissues).

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Sponges (phylum Porifera) exhibit a cellular grade of organization without true tissue differentiation.
- Their cells (choanocytes, pinacocytes, amoebocytes) are embedded in a gelatinous mesohyl without basement membranes or coordinated organ systems.

Why other options are incorrect:

- **Option A:** Flatworms are triploblastic eumetazoans possessing organs and organized tissues.
- **Option C:** Cnidarians are diploblastic eumetazoans with epidermis and gastrodermis tissue layers.
- **Option D:** Roundworms are triploblastic eumetazoans with distinct tissue and organ systems.

Question #33 Key: (A)BIOLOGY
03. Enzymes

Enzymes lower the activation energy by stabilizing the transition state of a metabolic reaction...

CORE CONCEPT & DERIVATION

Catalysis occurs within the active site through optimized chemical microenvironments (charge dispersion, hydrogen bonding, steric strain) that lower activation energy.

Formula / Rule / Reaction:

$$\Delta G_{\text{catalyzed}}^{\ddagger} < \Delta G_{\text{uncatalyzed}}^{\ddagger}$$

Solution:

- The catalytic pocket brings reacting groups into close proximity and optimal orientation.
- Active site amino acid residues donate or accept protons and establish favorable electrostatic interactions that stabilize the transition state.

Why other options are incorrect:

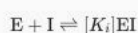
- **Option B:** The outer protein framework provides structural stability, but catalytic stabilization occurs at the active site.
- **Option C:** Active sites are formed by amino acid residues, not fatty acids.
- **Option D:** Allosteric sites mediate non-competitive enzyme regulation rather than transition-state stabilization.

Question #34 Key: (B)BIOLOGY
03. Enzymes

Competitive inhibitors compete with the:

CORE CONCEPT & DERIVATION

Competitive inhibitors possess a molecular geometry similar to the natural substrate, competing for the same active site.

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

- A competitive inhibitor shares structural homology with the substrate.
- It reversibly binds to the free enzyme's active site, preventing the substrate from forming an enzyme-substrate complex.

Why other options are incorrect:

- **Option A:** The inhibitor binds to the enzyme, rather than competing with it.
- **Option C:** Products are released following catalysis and do not serve as competitive substrates under initial velocity conditions.
- **Option D:** Coenzymes are organic prosthetic partners that assist catalysis rather than competing substrates.

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

Non-competitive inhibitor molecules have:

CORE CONCEPT & DERIVATION

Non-competitive inhibitors target allosteric regulatory sites distinct from the catalytic pocket, requiring no structural similarity to the substrate.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Non-competitive inhibitors bind to allosteric sites on the enzyme or enzyme-substrate complex.
- Because they do not bind to the substrate-binding pocket, their chemical structure is completely different from the substrate.

Why other options are incorrect:

- **Option A:** Structural similarity to the substrate is the defining hallmark of competitive inhibitors.
- **Option C:** Non-competitive inhibitors do not bind within the active site.
- **Option D:** Non-competitive inhibitors do not possess a substrate-like conformation.

Question #36 Key: (B)BIOLOGY
03. Enzymes

A zinc ion is attached at the active site of the enzyme carboxypeptidase. The zinc ion function...

CORE CONCEPT & DERIVATION

Inorganic metal ions that reversibly or permanently associate with enzymes to participate directly in catalysis are termed enzyme activators (inorganic cofactors).

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Carboxypeptidase is a zinc metalloenzyme that hydrolyzes terminal peptide bonds.
- The Zn^{2+} ion coordinates directly with active site residues and polarizes the carbonyl bond of the substrate, acting as an inorganic activator.

Why other options are incorrect:

- **Option A:** Coenzymes are non-protein organic molecules (such as NAD^+ or coenzyme A), not inorganic metal ions.
- **Option C:** Zinc is an indispensable catalytic cofactor, not an inhibitor.
- **Option D:** Zinc resides directly inside the catalytic pocket, not at an allosteric site.

Question #37 Key: (C)BIOLOGY
03. Enzymes

What is the optimum physiological pH range for most human cellular enzymes?

CORE CONCEPT & DERIVATION

Most human intracellular enzymes function optimally near neutral physiological pH (7.2 to 7.4), with maximal catalytic activity spanning pH 6 to 8.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- At extreme pH values, alteration of amino acid ionization states disrupts tertiary conformation and denatures active sites.
- Except for gastric pepsin (pH 1.5 to 2.0) and intestinal trypsin (pH 8.0 to 9.0), most human cellular enzymes operate between pH 6.0 and 8.0.

Why other options are incorrect:

- **Option A:** pH 2 to 3 is restricted to the gastric lumen for pepsin activity.
- **Option B:** pH 3 to 5 denatures cellular proteins; only lysosomes maintain a luminal pH near 4.5 to 5.0.
- **Option D:** pH 8 to 10 represents alkaline conditions found in pancreatic secretions, not typical intracellular environments.

Question #38 Key: (B)BIOLOGY
16. Evolution

Adaptations that an organism acquires by its own actions during its lifespan without modifying ...

CORE CONCEPT & DERIVATION

Modifications acquired in somatic cells during an organism's life do not alter germline DNA sequences and cannot be transmitted to offspring.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Acquired phenotypic adaptations involve somatic physiological or behavioral responses to environmental stimuli.
- Because they do not alter the nucleotide sequence of gametic DNA in the germline, they are completely non-heritable.

Why other options are incorrect:

- **Option A:** Somatic characters acquired during life cannot be inherited by progeny (refuting Lamarckism).
- **Option C:** Somatic cell mutations or alterations cannot be transferred to germ cells for vertical inheritance.
- **Option D:** Without modification of gametic DNA, acquired somatic changes are never heritable.

Question #39 Key: (D)BIOLOGY
16. Evolution

For the evolutionary process of allopatric speciation to occur, which of the following is NOT a...

CORE CONCEPT & DERIVATION

Geographical barriers are physical topographical landforms or water bodies that fragment a contiguous population into geographically isolated demes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Oceans, rivers, and mountain ranges represent distinct physical geographic obstacles that block gene flow between separated populations.
- The atmosphere is an unbroken fluid envelope surrounding the entire planet and does not act as a physical geographical barrier isolating terrestrial populations.

Why other options are incorrect:

- **Option A:** Oceans physically isolate terrestrial populations on islands and continents.
- **Option B:** Wide rivers prevent gene exchange between populations on opposing banks.
- **Option C:** Mountain ranges present physical and climatic barriers separating lowland populations.

Question #40 Key: (D)BIOLOGY
16. Evolution

According to the Biogenetic Law of Ernst Haeckel:

CORE CONCEPT & DERIVATION

Haeckel's Biogenetic Law asserts that the embryonic developmental stages of an individual animal repeat the adult evolutionary history of its ancestral lineage.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Ernst Haeckel formalized this principle in the phrase: 'ontogeny recapitulates phylogeny'.
- Here, 'ontogeny' represents individual embryonic development, and 'phylogeny' represents the evolutionary history of the species.

Why other options are incorrect:

- **Option A:** 'Survival of the fittest' is the concept coined by Herbert Spencer describing natural selection.
- **Option B:** 'Use and disuse of organs' is the core tenet of Lamarck's evolutionary hypothesis.
- **Option C:** 'Phylogeny recapitulates ontogeny' reverses the statement of Haeckel's law.

Question #41 Key: (D)BIOLOGY
16. Evolution

The animal species on the Galapagos Islands most closely resemble species living on the:

CORE CONCEPT & DERIVATION

Island biogeography demonstrates that oceanic volcanic islands are colonized by ancestral species originating from the nearest continental mainland.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The Galapagos archipelago is situated approximately 900 km west of the South American nation of Ecuador.
- Colonizers migrated from the South American mainland and subsequently diverged into distinct endemic species through adaptive radiation.

Why other options are incorrect:

- **Option A:** Northern Europe belongs to a different biogeographical realm and shares no direct colonizing lineage with the Galapagos.
- **Option B:** Great Britain is located thousands of kilometers away in the North Atlantic.
- **Option C:** North America is more distant than South America, which provided the original founders.

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

Digested food from the small intestine is carried directly to the liver by the:

CORE CONCEPT & DERIVATION

The hepatic portal system directs venous blood draining intestinal capillaries into liver sinusoids for nutrient processing and detoxification before systemic circulation.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Capillary beds of the intestinal villi absorb monosaccharides, amino acids, and water-soluble vitamins.
- These capillaries converge into the superior mesenteric vein, joining the splenic vein to form the hepatic portal vein, which empties into the liver sinusoids.

Why other options are incorrect:

- **Option A:** The hepatic artery delivers oxygenated arterial blood from the celiac axis directly to the liver.
- **Option B:** The hepatic vein collects processed blood from liver sinusoids and drains into the inferior vena cava.
- **Option D:** 'Hepatic portal artery' is an anatomically non-existent vessel.

Question #43 Key: (D)BIOLOGY
08. Immunity

_____ proteins are produced by white blood cells in response to _____ and provide humoral immun...

CORE CONCEPT & DERIVATION

Humoral immunity is mediated by secreted immunoglobulin proteins (antibodies) produced by plasma cells upon stimulation by foreign macromolecules (antigens).

Formula / Rule / Reaction:

B-cell Activation → Plasma Cell → Antibody Release $\xrightarrow{\text{binds}}$ Antigen

Solution:

- Antigens are foreign molecules that provoke a specific adaptive immune response.
- Plasma cells (differentiated B-lymphocytes) produce matching antibodies (immunoglobulins) that bind, neutralize, or opsonize those antigens.

Why other options are incorrect:

- **Option A:** Antibiotics are chemical compounds synthesized by microorganisms or pharmaceutical methods, not by human leukocytes.
- **Option B:** Antibodies do not target normal red blood cells in healthy immune responses.
- **Option C:** Histamine is an inflammatory mediator, not an immunogenic stimulus that induces protective antibody production.

Question #44 Key: (C)BIOLOGY
07. Circulation / Transport

The lymphatic vessels of the body empty lymph into the bloodstream at the:

CORE CONCEPT & DERIVATION

Filtered interstitial fluid is returned to the cardiovascular system at the low-pressure venous angles where major lymphatic collecting ducts join the subclavian veins.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The thoracic duct empties into the venous system at the left subclavian vein (junction with left internal jugular vein).
- The right lymphatic duct empties into the right subclavian vein, returning lymph to systemic circulation.

Why other options are incorrect:

- **Option A:** Lymphatic trunks do not discharge into abdominal veins.
- **Option B:** The entrance occurs precisely at the venous angle of the subclavian vein.
- **Option D:** The bile duct delivers bile to the duodenum and has no connection to lymphatics.

Question #45 Key: (B)BIOLOGY
07. Circulation / Transport*Flow of blood entering the capillaries is adjusted by:***CORE CONCEPT & DERIVATION**

Microvascular capillary perfusion is regulated locally by rings of smooth muscle at the junctions where true capillaries branch from terminal arterioles or metarterioles.

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

- Pre-capillary sphincters consist of circular smooth muscle fibers at the origin of true capillaries.
- When contracted, blood bypasses the capillary bed via thoroughfare channels; when relaxed, blood flows into the capillary exchange network.

Why other options are incorrect:

- **Option A:** The heart generates systemic perfusion pressure but cannot adjust blood distribution to individual capillary beds.
- **Option C:** Metarterioles provide bypass thoroughfare pathways, while sphincters gate entry into the capillary branches.
- **Option D:** Venous valves prevent retrograde flow in veins and do not regulate arterial capillary entry.

Question #46 Key: (A)BIOLOGY
10. Homeostasis*The pressure exerted by a solution separated by a semipermeable membrane from pure water is termed...***CORE CONCEPT & DERIVATION**

Osmotic pressure is the precise hydrostatic pressure that must be applied to a solution to prevent the inward movement of pure water across an ideal semipermeable membrane.

Formula / Rule / Reaction:

$$\Pi = iCRT$$

Solution:

- Osmotic pressure (Π) is a colligative property proportional to the molar solute concentration of the solution.
- It represents the external pressure required to maintain equilibrium and counteract the chemical potential gradient of water.

Why other options are incorrect:

- **Option B:** Soil potential describes water matric potential within soil particles.
- **Option C:** Solute potential (Ψ_s) is the thermodynamic measure that decreases water potential and is always a negative value, whereas osmotic pressure is positive.
- **Option D:** Solvent potential is not a standard thermodynamic term.

Question #47 Key: (B)BIOLOGY
04. Bioenergetics*Which of the following is NOT a consequence of anaerobic respiration in human muscle cells?***CORE CONCEPT & DERIVATION**

Anaerobic glycolysis yields only 2 ATP per glucose molecule compared to 36 to 38 ATP produced in aerobic cellular respiration.

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

- Anaerobic glycolysis provides rapid but low energy output (2 ATP per glucose).
- It does not yield high amounts of cellular energy; accumulation of lactate and protons induces fatigue, cramps, and pain.

Why other options are incorrect:

- **Option A:** Muscle cramps occur due to local metabolic acidosis and calcium ion deregulation.
- **Option C:** Pain results from the stimulation of pain nociceptors by increased proton concentrations.
- **Option D:** Fatigue results from rapid glycogen depletion and cellular ATP exhaustion.

Question #48 Key: (A)BIOLOGY
09. Respiration / Gaseous Exchange*Respiratory surfaces across animals exhibit which of the following mandatory characteristics?***CORE CONCEPT & DERIVATION**

According to Fick's Law of Diffusion, efficient respiratory gas exchange surfaces must be thin, moist, highly vascularized, and fully permeable to gases.

Formula / Rule / Reaction:

$$\text{Rate of Diffusion} \propto \frac{A \times \Delta P}{T}$$

Solution:

- The respiratory membrane must be permeable to O_2 and CO_2 to permit passive diffusion down partial pressure gradients.
- In addition, respiratory surfaces must remain moist and present a large surface area with a thin diffusion path.

Why other options are incorrect:

- **Option B:** Respiratory membranes must be thin (less than $1 \mu\text{m}$) to minimize diffusion distance (T).
- **Option C:** Respiratory surfaces must be heavily vascularized to maintain steep partial pressure gradients.
- **Option D:** Respiratory surfaces require efficient ventilation mechanisms to refresh external air or water.

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

Which of the following organisms is a prokaryote?

CORE CONCEPT & DERIVATION

Prokaryotes are unicellular organisms that lack a membrane-bound nucleus and membrane-enclosed cytoplasmic organelles.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- *Escherichia coli* is a Gram-negative bacterium belonging to the domain Bacteria.
- It contains a single circular naked DNA chromosome (nucleoid), 70S ribosomes, and lacks a nuclear envelope, qualifying it as a prokaryote.

Why other options are incorrect:

- **Option A:** Protista is a kingdom of single-celled eukaryotic organisms.
- **Option C:** *Amoeba* is a eukaryotic protozoan containing a true nucleus and membrane-bound organelles.
- **Option D:** Fungi is a eukaryotic kingdom characterized by chitinous cell walls and linear chromosomes enclosed in nuclei.

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

What is the number of distinct structural layers present in the Gram-negative bacterial cell wall...

CORE CONCEPT & DERIVATION

The Gram-negative bacterial cell wall consists of two distinct structural layers: an inner thin peptidoglycan layer and an outer lipopolysaccharide membrane.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The inner layer is a thin peptidoglycan meshwork (approximately 2 to 7 nm) situated in the periplasmic space.
- The outer layer is an asymmetric lipid bilayer (outer membrane) containing phospholipids internally and lipopolysaccharides (LPS) externally.

Why other options are incorrect:

- **Option A:** A single thick layer of peptidoglycan is the defining feature of the Gram-positive cell wall.
- **Option C:** Three layers is an inaccurate description of the cell wall structure.
- **Option D:** Four layers does not conform to the established two-layer architecture of the Gram-negative cell wall.

Question #51 Key: (C)BIOLOGY
11. Support & Movement

The division of cocci in three perpendicular planes forms a sarcina, which is a cubical packet...

CORE CONCEPT & DERIVATION

Bacterial cellular arrangement depends on the number and orientation of planes of cell division.

Formula / Rule / Reaction:

$$N = 2^n = 2^3 = 8$$

Solution:

- When cocci divide sequentially in three mutually perpendicular planes, the resulting daughter cells remain adhered together.
- This produces a regular cubical packet consisting of exactly 8 individual cocci, designated as a sarcina.

Why other options are incorrect:

- **Option A:** Two cocci remaining attached after division in one plane form a diplococcus.
- **Option B:** Four cocci resulting from division in two perpendicular planes form a tetrad.
- **Option D:** Sixteen cocci represent a double sarcina or an irregular cluster, not the basic sarcina packet.

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

Which of the following statements is correct regarding human pulmonary ventilation at rest?

CORE CONCEPT & DERIVATION

Quiet breathing requires muscular contraction to enlarge thoracic volume, whereas resting expiration relies on passive elastic recoil.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Resting inspiration requires active contraction of the diaphragm and external intercostal muscles, consuming metabolic ATP energy.
- Normal resting expiration is entirely passive, driven by the elastic recoil of the lungs and thoracic cage without active muscular effort.

Why other options are incorrect:

- **Option B:** Resting expiration is passive, becoming active only during forced expiration (exercise, coughing).
- **Option C:** Inspiration requires muscular work to lower alveolar pressure below atmospheric pressure and cannot occur passively.
- **Option D:** Inspiration is an active process requiring sustained muscular contraction.

Question #53 Key: (B)BIOLOGY
06. Digestion/Nutrition

Nitrifying bacteria are classified physiologically as:

CORE CONCEPT & DERIVATION

Chemotrophic autotrophs (chemosynthetic bacteria) obtain metabolic energy from the chemical oxidation of inorganic compounds rather than radiant sunlight.

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

- Nitrifying bacteria oxidize inorganic ammonia into nitrite (Nitrosomonas) and nitrite into nitrate (Nitrobacter).
- They trap the liberated chemical energy to fix carbon dioxide into organic carbohydrates, qualifying as chemosynthetic autotrophs.

Why other options are incorrect:

- Option A:** Heterotrophic bacteria require preformed organic carbon compounds for growth.
- Option C:** Saprophytic bacteria decompose dead organic material for nutrition.
- Option D:** Parasitic bacteria derive nutrition directly from living host tissues.

Question #54 Key: (D)BIOLOGY
14. Reproduction

Each human testis is divided by fibrous septa into approximately:

CORE CONCEPT & DERIVATION

Fibrous septa extending inward from the tunica albuginea partition the testicular parenchyma into discrete anatomical compartments called lobules.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The dense fibrous capsule of the testis (tunica albuginea) projects inward to form connective tissue septa.
- These septa partition each human testis into 250 to 300 lobules, each containing one to four highly coiled seminiferous tubules.

Why other options are incorrect:

- Option A:** 50 to 100 lobules significantly underrepresents testicular compartmentalization.
- Option B:** 150 to 200 lobules is below the accepted anatomical count.
- Option C:** 200 to 250 lobules is incomplete; standard textbooks specify 250 to 300 lobules.

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

Which cells in human males are responsible for the secretion of testosterone?

CORE CONCEPT & DERIVATION

Testicular androgen production is performed by interstitial Leydig cells in response to luteinizing hormone (LH).

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Leydig cells (interstitial cells) reside in the loose vascular connective tissue between seminiferous tubules.
- In response to pituitary LH stimulation, they synthesize and secrete testosterone directly into neighboring capillaries.

Why other options are incorrect:

- Option A:** Pituitary gonadotrophs secrete LH and FSH, not steroid androgens.
- Option B:** Hypothalamic neurosecretory neurons synthesize and release GnRH.
- Option C:** Sertoli cells nurse developing spermatids and secrete androgen-binding protein and inhibin.

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

The fertilized ovum is implanted and undergoes embryonic development within the:

CORE CONCEPT & DERIVATION

Fertilization occurs within the fallopian tube, but blastocyst implantation and gestation take place within the endometrium of the uterus.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The developing blastocyst travels through the fallopian tube and implants into the glandular endometrium of the uterus around day 6 to 7 post-conception.
- The uterus provides the vascular and nutritional support required for subsequent embryonic and fetal development.

Why other options are incorrect:

- Option A:** The ovary produces secondary oocytes; implantation here represents an ectopic ovarian pregnancy.
- Option C:** The oviduct (fallopian tube) is the site of fertilization; implantation here results in an ectopic tubal pregnancy.
- Option D:** The cervix is the muscular inferior neck of the uterus that remains closed to retain the fetus until parturition.

Question #57 Key: (C)BIOLOGY
14. Reproduction

The blood concentration of luteinizing hormone (LH) reaches its maximum peak during which stage...

CORE CONCEPT & DERIVATION

Sustained high estradiol levels from the dominant mature follicle trigger an LH surge that induces ovulation near the midpoint of the cycle.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Rising estrogen levels exert positive feedback on the anterior pituitary and hypothalamus around day 12 to 13.
- This triggers a sharp LH surge that peaks 10 to 12 hours prior to follicular rupture, defining the ovulation stage.

Why other options are incorrect:

- **Option A:** During menstruation (days 1 to 5), LH levels are low and basal.
- **Option B:** During the proliferative (follicular) stage, LH increases gradually but does not reach its maximum peak.
- **Option D:** During the secretory (luteal) stage, progesterone and estrogen exert negative feedback, suppressing LH release.

Question #58 Key: (D)BIOLOGY
14. Reproduction

The major mode of transmission of syphilis is:

CORE CONCEPT & DERIVATION

Treponema pallidum is an obligate parasitic spirochete requiring direct human mucous membrane contact for transmission.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Syphilis is a sexually transmitted infection caused by *Treponema pallidum*.
- Transmission occurs predominantly via direct mucosal or skin contact with infectious primary chancres during sexual intercourse.

Why other options are incorrect:

- **Option A:** Transmission by blood transfusion is rare due to standard modern serological donor screening.
- **Option B:** *Treponema pallidum* is not transmitted by arthropod or insect vectors.
- **Option C:** The bacterium is extremely sensitive to drying and cannot survive in water or outside the host.

Question #59 Key: (A)BIOLOGY
11. Support & Movement

Which of the following statements is FALSE regarding cartilage?

CORE CONCEPT & DERIVATION

Cartilage is an avascular skeletal connective tissue that relies entirely on passive diffusion through its extracellular matrix for nourishment.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Mature cartilage is avascular, containing no blood vessels or lymphatic channels within its matrix.
- Chondrocytes receive nutrients and oxygen solely by slow diffusion from blood vessels in the surrounding perichondrium or synovial fluid.

Why other options are incorrect:

- **Option B:** Cartilage is a specialized supporting skeletal connective tissue.
- **Option C:** Articular hyaline cartilage covers the articulating ends of bones in synovial joints.
- **Option D:** Cartilage contains a non-mineralized collagenous matrix, making it more pliable and softer than mineralized bone.

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

Which of the following muscle components serves as a high-energy phosphate reservoir for rapid ...

CORE CONCEPT & DERIVATION

Phosphocreatine (creatine phosphate) provides an immediate intracellular reservoir of high-energy phosphate bonds to phosphorylate ADP during initial muscular activity.

Formula / Rule / Reaction:

$\text{Creatine Phosphate} + \text{ADP} \rightarrow \text{Creatine} + \text{ATP}$

Solution:

- Resting skeletal muscle stores five to six times more creatine phosphate than free ATP.
- During the first few seconds of muscle contraction, creatine kinase transfers a high-energy phosphate from creatine phosphate to ADP to regenerate ATP.

Why other options are incorrect:

- **Option A:** Free cellular ATP is rapidly depleted within 1 to 2 seconds of vigorous contraction and is not a storage reservoir.
- **Option C:** Myoglobin is an intracellular hemoprotein that stores oxygen, not high-energy phosphate bonds.
- **Option D:** Creatinine is an excretory breakdown waste product of creatine metabolism, not a phosphate storage compound.

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

Which of the following is NOT found within skeletal muscle fibers in humans?

CORE CONCEPT & DERIVATION

Skeletal muscle fibers contain myoglobin for intracellular oxygen storage; hemoglobin is restricted strictly to erythrocytes within blood vessels.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Hemoglobin is confined exclusively within circulating red blood cells in the microvasculature outside muscle fibers.
- Skeletal muscle fibers contain myoglobin, a monomeric heme protein adapted to store oxygen within the sarcoplasm.

Why other options are incorrect:

- **Option A:** Skeletal muscle fibers are multinucleated syncytia formed by the developmental fusion of myoblasts.
- **Option B:** Skeletal muscle fibers contain abundant mitochondria (sarcosomes) to generate ATP for contraction.
- **Option C:** Skeletal muscle fibers (especially slow-twitch type I fibers) contain large amounts of myoglobin.

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

A hinge joint is present between which of the following articulating bones?

CORE CONCEPT & DERIVATION

A hinge joint is a uniaxial synovial joint that restricts angular movement to a single plane (flexion and extension).

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The elbow joint operates as a hinge joint where the trochlea of the humerus articulates with the trochlear notch of the ulna.
- This anatomical arrangement permits movement in only one plane (flexion and extension).

Why other options are incorrect:

- **Option B:** The femur articulates with the pelvic girdle, not the pectoral girdle.
- **Option C:** The hip joint between the femoral head and pelvic acetabulum is a multiaxial ball-and-socket joint.
- **Option D:** The shoulder joint between the humerus and glenoid cavity of the pectoral girdle is a multiaxial ball-and-socket joint.

Question #63 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

A test cross is performed to determine whether an individual displaying a dominant phenotype is...

CORE CONCEPT & DERIVATION

A test cross involves crossing an individual displaying a dominant phenotype with a known homozygous recessive individual.

Formula / Rule / Reaction:If $TT \times tt \rightarrow 100\%$ dominant; if $Tt \times tt \rightarrow 1 : 1$ dominant : recessive**Solution:**

- An individual with a dominant phenotype may have genotype TT or Tt .
- Crossing this individual with a homozygous recessive tester (tt) allows the hidden recessive allele to be expressed phenotypically in the offspring if present.

Why other options are incorrect:

- **Option A:** At is non-standard genetic notation and does not represent a homozygous recessive tester.
- **Option C:** AB represents a co-dominant or heterozygous individual, not a recessive tester.
- **Option D:** Crossing with a homozygous dominant individual (TT) masks all recessive alleles, yielding 100% dominant offspring regardless of the unknown genotype.

Question #64 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics

What clinical complication can occur when an [Formula]-negative woman conceives a child who is...

CORE CONCEPT & DERIVATIONEntry of fetal Rh^+ erythrocytes into an Rh^- maternal circulation induces anti-Rh IgG synthesis, which can cause hemolytic disease of the newborn in subsequent pregnancies.**Formula / Rule / Reaction:**

Factual recall / Qualitative concept.

Solution:

- Fetal Rh^+ erythrocytes entering an Rh^- mother during delivery trigger maternal sensitization and anti-D antibody production.
- In a subsequent Rh^+ pregnancy, maternal anti-D IgG antibodies cross the placenta and lyse fetal red blood cells, resulting in maternal-fetal Rh incompatibility (erythroblastosis fetalis).

Why other options are incorrect:

- **Option B:** The immune reaction occurs between maternal circulating antibodies and fetal antigens, not paternal tissues.
- **Option C:** Rh incompatibility is an isoimmune hemolytic anemia, not a malignant neoplasm.
- **Option D:** Rh incompatibility threatens fetal survival through severe anemia, but does not cause immediate maternal death.

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

DNA stores hereditary biological information in discrete functional units termed:

CORE CONCEPT & DERIVATION

A gene is the fundamental physical and functional unit of heredity, consisting of a specific linear nucleotide sequence encoding a functional polypeptide or RNA.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Hereditary instructions in DNA are organized into discrete segments called genes.
- Each gene contains the specific coding sequence required to direct the synthesis of a protein or functional RNA molecule.

Why other options are incorrect:

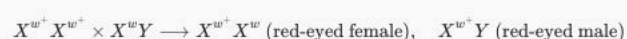
- **Option B:** Phenotypes are the observable physical, biochemical, and physiological traits of an organism.
- **Option C:** A karyotype is a systematic visual display of the complete chromosome complement of an individual.
- **Option D:** Cells are the basic structural and functional units of living organisms, not units of DNA storage.

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

In his studies on sex linkage in *Drosophila melanogaster*, Thomas Hunt Morgan crossed w...

CORE CONCEPT & DERIVATION

In X-linked inheritance, wild-type red eye color is completely dominant to white eye color; maternal homozygous dominant alleles are transmitted to all progeny.

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

- The homozygous red-eyed female parent produces eggs carrying only the dominant X^{w+} allele.
- All F_1 females receive X^{w+} from the mother and X^w from the father, displaying red eyes.
- All F_1 males receive X^{w+} from the mother and Y from the father, displaying red eyes.
- Therefore, 100% of the F_1 offspring (both males and females) are red-eyed.

Why other options are incorrect:

- **Option B:** White-eyed males appear in the F_1 only in the reciprocal cross (white-eyed female $\times$ red-eyed male).
- **Option C:** White-eyed females require two recessive X^w alleles and cannot appear in this F_1 generation.
- **Option D:** White eyes is a recessive trait masked completely by the dominant maternal allele.

Question #67 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

Which one of the following human genetic conditions is inherited as an X-linked dominant disorder...

CORE CONCEPT & DERIVATION

X-linked dominant disorders manifest in both hemizygous males and heterozygous females; affected fathers transmit the condition to all daughters and no sons.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Hypophosphatemic rickets (vitamin D-resistant rickets) is caused by mutations in the PHEX gene on the X chromosome.
- It is inherited in an X-linked dominant pattern with high penetrance.

Why other options are incorrect:

- **Option A:** Hemophilia A is an X-linked recessive coagulopathy.
- **Option B:** Red-green color blindness is an X-linked recessive photoreceptor disorder.
- **Option D:** Becker muscular dystrophy is an X-linked recessive dystrophinopathy.

Question #68 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

The mode of inheritance of genetic traits in humans cannot be studied by controlled experiments...

CORE CONCEPT & DERIVATION

Because controlled experimental matings cannot be performed in human genetics, family lineages are evaluated using standardized pedigree charts.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Pedigree analysis tracks the generational occurrence of phenotypes within a family tree.
- By analyzing inheritance patterns, geneticists determine whether a trait is autosomal dominant, autosomal recessive, X-linked, or mitochondrial.

Why other options are incorrect:

- **Option A:** Controlled experimental breeding is unethical and impossible in human populations.
- **Option B:** Chi-square tests evaluate goodness-of-fit for statistical hypothesis testing, but do not trace family trees.
- **Option D:** Probability analysis calculates inheritance risks once the transmission mode is established.

Question #69 Key: (B)CHEMISTRY
01. Stoichiometry

One atomic mass unit ([Formula]) is defined as:

CORE CONCEPT & DERIVATION

The unified atomic mass unit is defined relative to the mass of an unbound neutral carbon-12 atom in its nuclear ground state.

Formula / Rule / Reaction:

$$1 \text{ a.m.u.} = \frac{1}{12} \times m(^{12}\text{C}) \approx 1.66054 \times 10^{-27} \text{ kg}$$

Solution:

- By international IUPAC convention, one atomic mass unit equals one-twelfth the mass of a single carbon-12 atom at rest.
- Carbon-12 is assigned an exact mass of 12.000 atomic mass units.

Why other options are incorrect:

- **Option A:** An atom of carbon-12 has a mass of 12 a.m.u., not 1 a.m.u.
- **Option C:** Hydrogen was an earlier mass standard replaced by carbon-12 in 1961.
- **Option D:** Atoms of different chemical elements possess distinctly different nuclear masses.

Question #70 Key: (C)

CHEMISTRY
01. Stoichiometry

A compound of sodium oxide contains [Formula] sodium and [Formula] oxygen by mass. What is the ...

CORE CONCEPT & DERIVATION

The empirical formula represents the simplest whole-number molar ratio of atoms in a chemical substance.

Formula / Rule / Reaction:

$$n = \frac{\text{Mass}}{\text{Molar Mass}}$$

Solution:

- In a 100 g sample:
- Moles of Na = $\frac{74.2 \text{ g}}{23.0 \text{ g/mol}} = 3.226 \text{ mol}$
- Moles of O = $\frac{25.8 \text{ g}}{16.0 \text{ g/mol}} = 1.6125 \text{ mol}$
- Divide by the smallest value: Na = $\frac{3.226}{1.6125} = 2.0$, O = $\frac{1.6125}{1.6125} = 1.0$.
- The simplest molar ratio is 2 : 1, yielding Na₂O.

Why other options are incorrect:

- **Option A:** NaO reflects a 1:1 molar ratio (approximately 59% Na, 41% O).
- **Option B:** NaO₂ reflects sodium superoxide (41.8% Na, 58.2% O).
- **Option D:** Na₂O₂ is a molecular formula with the empirical formula NaO.

Question #71 Key: (B)

CHEMISTRY
01. Stoichiometry

A sample of [Formula] of 2-propanol was oxidized with excess acidified [Formula] under reflux. ...

CORE CONCEPT & DERIVATION

Oxidation of a secondary alcohol produces a ketone; actual yield equals theoretical yield multiplied by fractional yield.

Formula / Rule / Reaction:



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

Solution:

- Molar mass of 2-propanol (C₃H₈O) = 60.0 g/mol.
- Moles of 2-propanol = $\frac{30.0 \text{ g}}{60.0 \text{ g/mol}} = 0.50 \text{ mol}$.
- Theoretical moles of propanone (C₃H₆O, 58.0 g/mol) = 0.50 mol.
- Theoretical mass = 0.50 mol × 58.0 g/mol = 29.0 g.
- Actual yield = 29.0 g × 0.750 = 21.75 g.

Why other options are incorrect:

- **Option A:** 1.74 g represents a calculation error in decimal scaling.
- **Option C:** 2.74 g is incorrect and does not reflect a 75% yield from 0.5 mol reactant.
- **Option D:** 29.0 g represents the 100% theoretical yield without factoring in the 75% yield.

Question #72 Key: (D)CHEMISTRY
02. Atomic Structure

According to which scientist is the wave mechanical probability of finding an electron at a spe...

CORE CONCEPT & DERIVATION

Erwin Schrödinger formulated wave mechanics, in which the square of the wave function (ψ^2) represents electron probability density.

Formula / Rule / Reaction:

$$\hat{H}\psi = E\psi, \quad P = |\psi|^2 dV$$

Solution:

- Erwin Schrödinger developed the fundamental quantum wave equation treating electrons as three-dimensional matter waves.
- The probability of locating an electron in a given differential volume element is proportional to $|\psi|^2$, defining atomic orbitals.

Why other options are incorrect:

- Option A:** Niels Bohr proposed fixed planetary circular orbits with well-defined classical electron trajectories.
- Option B:** Louis de Broglie introduced the dual matter-wave hypothesis ($\lambda = h/p$) without formulating the probability wave equation.
- Option C:** Friedrich Hund formulated empirical rules for filling degenerate atomic orbitals.

Question #73 Key: (C)CHEMISTRY
02. Atomic Structure

Which gas present in a gas discharge tube produces the lightest canal ray particles (positive i...

CORE CONCEPT & DERIVATION

Canal rays consist of positive residual ions of the gas present in the discharge tube; their mass corresponds to the atomic mass of the gas used.

Formula / Rule / Reaction:

$$\frac{e}{m} = \frac{q}{m_{\text{ion}}}$$

Solution:

- Canal rays are formed when cathode rays ionize gas molecules inside the discharge tube.
- Hydrogen gas produces protons (H^+), which possess the lowest atomic mass (1 a.m.u.) and the highest charge-to-mass ratio of any positive ion.

Why other options are incorrect:

- Option A:** Argon produces Ar^+ ions with an atomic mass of 40 a.m.u.
- Option B:** Helium produces He^+ ions with an atomic mass of 4 a.m.u.
- Option D:** Neon produces Ne^+ ions with an atomic mass of 20 a.m.u.

Question #74 Key: (A)CHEMISTRY
02. Atomic Structure

Which chemical element possesses the ground state electronic configuration [Formula]?

CORE CONCEPT & DERIVATION

The ground state electronic configuration reflects the aufbau distribution of electrons corresponding to the atomic number of the neutral element.

Formula / Rule / Reaction:

$$Z = 2 + 2 + 6 + 2 + 6 = 18$$

Solution:

- Summing the orbital electron superscripts yields the total atomic number: $2 + 2 + 6 + 2 + 6 = 18$.
- Atomic number 18 corresponds to the noble gas argon (Ar), which features a filled valence shell.

Why other options are incorrect:

- Option B:** Chlorine has $Z = 17$ with configuration $[\text{Ne}] 3s^2 3p^5$.
- Option C:** Sodium has $Z = 11$ with configuration $[\text{Ne}] 3s^1$.
- Option D:** Sulfur has $Z = 16$ with configuration $[\text{Ne}] 3s^2 3p^4$.

Question #75 Key: (D)CHEMISTRY
02. Atomic Structure

What is the atomic number ([Formula]) of a transition metal element that contains four unpair...

CORE CONCEPT & DERIVATION

Degenerate d-orbitals are filled singly before pairing begins (Hund's rule); iron ($Z = 26$) contains four unpaired d-electrons.

Formula / Rule / Reaction:

$$\text{Fe } (Z = 26) : [\text{Ar}] 3d^6 4s^2$$

Solution:

- Iron ($Z = 26$) has the valence configuration $3d^6 4s^2$.
- Distributing 6 electrons across the 5 degenerate d-orbitals gives one doubly occupied orbital and four singly occupied orbitals.
- This produces exactly four unpaired electrons.

Why other options are incorrect:

- Option A:** Carbon ($Z = 6$) has configuration $1s^2 2s^2 2p^2$ with two unpaired electrons.
- Option B:** Silicon ($Z = 14$) has configuration $[\text{Ne}] 3s^2 3p^2$ with two unpaired electrons.
- Option C:** Titanium ($Z = 22$) has configuration $[\text{Ar}] 3d^2 4s^2$ with two unpaired d-electrons.

Question #76 Key: (C)

CHEMISTRY
04. Gases

A gaseous mixture contains [Formula], [Formula], and [Formula] by volume. If the total pressure is...

CORE CONCEPT & DERIVATION

By Dalton's and Amagat's laws, the partial pressure of a gas in an ideal mixture equals its mole fraction (volume fraction) multiplied by the total pressure.

Formula / Rule / Reaction:

$$P_i = X_i \times P_{\text{total}} = \left(\frac{\% \text{ by volume}}{100} \right) \times P_{\text{total}}$$

Solution:

- The volume percentage of hydrogen gas is 67.8%, giving a mole fraction of $X_{\text{H}_2} = \frac{67.8}{100}$.
- Applying Dalton's law: $P_{\text{H}_2} = \frac{67.8 \times 50}{100} \text{ atm} = 33.9 \text{ atm}$.

Why other options are incorrect:

- Option A:** Inverts the relationship by dividing by the total pressure.
- Option B:** Multiplies total pressure by unity, completely ignoring the hydrogen fraction.
- Option D:** Adds the percentage directly to total pressure, which is dimensionally incorrect.

Question #77 Key: (D)

CHEMISTRY
04. Gases

If we want to raise the temperature of one mole of an ideal gas by one Kelvin at constant pressure...

CORE CONCEPT & DERIVATION

For an ideal gas undergoing isobaric expansion, the work done per mole per Kelvin equals the ideal gas constant R .

Formula / Rule / Reaction:

$$W = P\Delta V = nR\Delta T = (1)(R)(1) = R$$

Solution:

- When one mole of gas is heated by 1 K, the expansion work is $W = R\Delta T = R$.
- Expressed in atmospheric units, $R = 0.0821 \text{ dm}^3 \cdot \text{atm}/(\text{mol} \cdot \text{K})$.
- Therefore, the gas expends $0.0821 \text{ dm}^3 \cdot \text{atm}$ of mechanical work.

Why other options are incorrect:

- Option A:** In Joules, the work done equals 8.314 J, not 0.0821 J.
- Option B:** 8.314 is the numerical value in $\text{J}/(\text{mol} \cdot \text{K})$, not in $\text{dm}^3 \cdot \text{atm}$.
- Option C:** 0.0821 kJ equals 82.1 J, which is incorrect.

Question #78 Key: (A)

CHEMISTRY
04. Gases

Heat flow between two interacting gases continues until all molecules in both systems attain the same average translational kinetic energy.

CORE CONCEPT & DERIVATION

Thermodynamic temperature is a direct measure of the average translational kinetic energy of gas molecules; thermal equilibrium requires equal average translational kinetic energy.

Formula / Rule / Reaction:

$$\overline{\text{KE}}_{\text{trans}} = \frac{3}{2} k_B T$$

Solution:

- Heat energy transfers spontaneously from the hotter gas to the colder gas until thermal equilibrium is established.
- At thermal equilibrium, the temperatures become equal, which means the average translational kinetic energy of the molecules is identical in both systems.

Why other options are incorrect:

- Option B:** Rotational kinetic energy depends on molecular geometry and does not define temperature.
- Option C:** Ideal gas molecules exert no intermolecular forces, making intermolecular potential energy zero.
- Option D:** Vibrational modes are inactive at standard temperatures and do not define the thermal equilibrium condition.

Question #79 Key: (D)CHEMISTRY
05. Liquids

Variation in the strength of intermolecular dipole-dipole forces directly alters many bulk phys...

CORE CONCEPT & DERIVATION

Intermolecular forces govern physical state transitions and enthalpies, whereas the number of moles depends strictly on the mass and molar mass of the sample.

Formula / Rule / Reaction:

$$n = \frac{m}{M}$$

Solution:

- Boiling point, heat of vaporization, and heat of sublimation depend directly on the energy required to overcome intermolecular attractions.
- The number of moles is an extensive chemical quantity independent of intermolecular forces.

Why other options are incorrect:

- Option A:** Stronger dipole-dipole forces require more thermal energy to separate liquid molecules, raising the boiling point.
- Option B:** Enthalpy of vaporization increases directly with increasing intermolecular attractive forces.
- Option C:** Heat of sublimation reflects the energy required to disrupt lattice attractions, which depend on intermolecular forces.

Question #80 Key: (A)CHEMISTRY
05. Liquids

Which of the following factors does NOT affect the magnitude of the equilibrium vapor pressure ...

CORE CONCEPT & DERIVATION

Equilibrium vapor pressure is an intensive thermodynamic property that depends only on temperature and the chemical nature of the substance, independent of surface area or liquid volume.

Formula / Rule / Reaction:

$$\ln P = -\frac{\Delta H_{\text{vap}}}{RT} + C$$

Solution:

- Vapor pressure represents a dynamic equilibrium between the rates of evaporation and condensation.
- As long as both liquid and vapor phases are present in a closed container at constant temperature, altering the total amount of liquid does not shift the equilibrium vapor pressure.

Why other options are incorrect:

- Option B:** Molecular size alters polarizability and dispersion forces, changing vapor pressure.
- Option C:** Vapor pressure increases exponentially with temperature according to the Clausius-Clapeyron equation.
- Option D:** Stronger intermolecular forces reduce evaporation rates, directly lowering vapor pressure.

Question #81 Key: (B)CHEMISTRY
06. Solids

The smallest fundamental repeating geometric block that contains the complete structural and sy...

CORE CONCEPT & DERIVATION

A crystal lattice is generated by the periodic three-dimensional translation of an elementary geometric building block called the unit cell.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The unit cell is the smallest repeating unit defined by edge lengths (a , b , c) and interaxial angles (α , β , γ).
- Translating the unit cell repeatedly in three dimensions reproduces the entire crystal lattice.

Why other options are incorrect:

- Option A:** 'Cell' is an ambiguous general term without specific crystallographic meaning.
- Option C:** The crystal lattice is the complete three-dimensional array of periodic points.
- Option D:** 'Crystal unit' is an informal term, not standard crystallographic terminology.

Question #82 Key: (A)CHEMISTRY
06. Solids

Which class of crystalline solids is also categorized as atomic network solids?

CORE CONCEPT & DERIVATION

Covalent network solids (such as diamond, quartz, and silicon carbide) consist of individual neutral atoms joined throughout the lattice by covalent bonds.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Covalent solids consist of atoms linked continuously by directional covalent bonds into an extended lattice network.
- Because the lattice points are occupied by neutral atoms rather than ions or discrete molecules, they are classified as atomic network solids.

Why other options are incorrect:

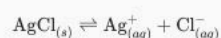
- **Option B:** Ionic solids consist of alternating cations and anions held by non-directional electrostatic forces.
- **Option C:** Metallic solids consist of positive metal ions immersed in a sea of delocalized electrons.
- **Option D:** Molecular solids consist of discrete covalent molecules held by weak intermolecular forces.

Question #83 Key: (C)CHEMISTRY
07. Equilibrium

The decrease in the solubility of a sparingly soluble salt caused by the addition of a soluble...

CORE CONCEPT & DERIVATION

According to Le Chatelier's principle, introducing an ion involved in a dissolution equilibrium shifts the equilibrium to the left, suppressing salt solubility.

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

- Introducing an electrolyte sharing a common ion (such as adding NaCl to a saturated AgCl solution) increases the common ion concentration.
- This causes the ionic product to exceed K_{sp} , shifting the dissolution equilibrium to the left and precipitating the salt.

Why other options are incorrect:

- **Option A:** Le Chatelier's principle is the broad thermodynamic rule governing equilibrium perturbations; the common ion effect is a specific application.
- **Option B:** The solubility product (K_{sp}) is the temperature-dependent equilibrium constant, which remains unchanged.
- **Option D:** The distribution law governs solute partitioning between two immiscible solvent phases.

Question #84 Key: (B)CHEMISTRY
07. EquilibriumPrecipitation of a sparingly soluble salt from solution occurs when the ionic product (Q_{sp}) is greater than the solubility product (K_{sp}).**CORE CONCEPT & DERIVATION**

Precipitation occurs when a solution becomes supersaturated, meaning the ionic product of dissolved ions exceeds the thermodynamic solubility product.

Formula / Rule / Reaction:

$$Q_{sp} > K_{sp} \implies \text{Precipitation occurs}$$

Solution:

- If $Q_{sp} < K_{sp}$, the solution is unsaturated and no precipitate can form.
- If $Q_{sp} = K_{sp}$, the solution is in dynamic equilibrium (saturated).
- If $Q_{sp} > K_{sp}$, the solution is supersaturated; excess ions precipitate as solid until $Q_{sp} = K_{sp}$.

Why other options are incorrect:

- **Option A:** When $Q_{sp} < K_{sp}$, the solution is unsaturated and more solid can dissolve.
- **Option C:** When $Q_{sp} = K_{sp}$, the solution is at dynamic saturation without net precipitation.
- **Option D:** Precipitation cannot occur at low concentrations where $Q_{sp} \leq K_{sp}$.

Question #85 Key: (A)CHEMISTRY
07. Equilibrium

The direction in which a chemical equilibrium shifts in response to a change in concentration, ...

CORE CONCEPT & DERIVATION

When an external stress is applied to a chemical system at equilibrium, the system shifts in the direction that minimizes or counteracts the applied stress.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Le Chatelier's principle states that modifying equilibrium variables (concentration, pressure, volume, temperature) causes the system to adjust to counteract the change.
- This principle predicts whether forward or reverse reactions will be favored.

Why other options are incorrect:

- Option B:** The law of mass action relates reaction rates to active masses of reactants, defining the equilibrium constant.
- Option C:** Hess's law states that overall reaction enthalpy is path-independent.
- Option D:** The law of heat of formation applies to standard thermochemical enthalpy calculations.

Question #86 Key: (C)CHEMISTRY
08. Reaction Kinetics

What is the overall reaction order for the rate equation: [Formula] ?

CORE CONCEPT & DERIVATION

The overall reaction order is the sum of the exponent powers of all reactant concentration terms in the experimental rate law.

Formula / Rule / Reaction:

$$\text{Overall Order} = m + n$$

Solution:

- The exponent for $[\text{H}_2]$ is 1.
- The exponent for $[\text{NO}_2]$ is 2.
- Overall reaction order = $1 + 2 = 3$ (third order).

Why other options are incorrect:

- Option A:** Order 1 considers only the hydrogen term and ignores nitrogen dioxide.
- Option B:** Order 2 considers only the nitrogen dioxide term and ignores hydrogen.
- Option D:** Order 4 incorrectly overcounts the sum of the exponents.

Question #87 Key: (B)CHEMISTRY
08. Reaction Kinetics

Catalysis in which the catalyst and the reacting chemical species exist in the same physical phase...

CORE CONCEPT & DERIVATION

Catalytic processes are categorized as homogeneous when the catalyst and all reactants form a single uniform physical phase.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In homogeneous catalysis, the catalyst is dissolved in or miscible with the reaction mixture, forming a single physical phase (liquid or gas).
- An example is the liquid-phase hydrolysis of esters catalyzed by aqueous hydrochloric acid.

Why other options are incorrect:

- Option A:** Heterogeneous catalysis involves catalysts and reactants in different physical phases (such as solid platinum catalyzing gaseous reactions).
- Option C:** Enzymatic adsorption catalysis typically involves macromolecular interfaces.
- Option D:** Autocatalysis describes a reaction where a generated product acts as the catalyst, irrespective of phase uniformity.

Question #88 Key: (C)CHEMISTRY
09. Thermochemistry

The Born-Haber cycle used to evaluate the lattice energies of ionic crystals represents an expe...

CORE CONCEPT & DERIVATION

The Born-Haber cycle applies Hess's law of constant heat summation to determine the lattice energy of an ionic compound through an indirect thermodynamic cycle.

Formula / Rule / Reaction:

$$\Delta H_f^\circ = \Delta H_{\text{sub}} + \text{IE} + \frac{1}{2}\text{BDE} + \text{EA} + U_{\text{lattice}}$$

Solution:

- Lattice energy cannot be determined directly by experiment.
- The Born-Haber cycle uses Hess's law to relate the standard enthalpy of formation to atomization, ionization, electron affinity, and lattice enthalpies.

Why other options are incorrect:

- Option A:** Henry's law governs the solubility of gases in liquids as a function of partial pressure.
- Option B:** Le Chatelier's principle predicts dynamic equilibrium shifts under stress.
- Option D:** The common ion effect describes the suppression of salt solubility by a shared ion.

Question #89 Key: (D)

CHEMISTRY
09. Thermochemistry

Which of the following thermodynamic quantities is a state function?

CORE CONCEPT & DERIVATION

A state function is a thermodynamic property that depends only on the current equilibrium state of the system, independent of the path taken to reach that state.

Formula / Rule / Reaction:

$$\Delta H = H_{\text{final}} - H_{\text{initial}}$$

Solution:

- Enthalpy ($H = U + PV$) is defined by fundamental state variables, making its value dependent only on initial and final states.
- Path-dependent quantities like work (w) and heat (q) vary according to the specific path taken.

Why other options are incorrect:

- Option A:** Work done is a path-dependent process variable.
- Option B:** Heat absorbed depends on the pathway and process conditions.
- Option C:** Frictional dissipation is an irreversible path-dependent loss.

Question #90 Key: (B)

CHEMISTRY
10. Electrochemistry

The operation of an electrochemical cell (galvanic or electrolytic) is fundamentally based upon...

CORE CONCEPT & DERIVATION

Electrochemical cells interconvert chemical and electrical energy via separated oxidation and reduction half-reactions that transfer electrons through an external circuit.

Formula / Rule / Reaction:



Solution:

- Electrochemical cells rely on oxidation (loss of electrons) occurring at the anode and reduction (gain of electrons) occurring at the cathode.
- Directing these electron transfers through an external conductor generates electrical current or drives non-spontaneous reactions.

Why other options are incorrect:

- Option A:** Acid-base reactions involve proton transfers without changes in oxidation states.
- Option C:** Nuclear transmutations involve subatomic nuclear rearrangements, not valence electron transfers.
- Option D:** Precipitation involves ion combination without electron transfer.

Question #91 Key: (C)

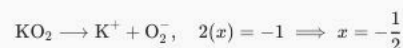
CHEMISTRY
11. S & P Block Elements

In which of the following chemical compounds does oxygen exhibit a fractional oxidation state?

CORE CONCEPT & DERIVATION

In superoxides, the superoxide anion (O_2^-) carries a net -1 charge, assigning each oxygen atom a formal fractional oxidation state of $-\frac{1}{2}$.

Formula / Rule / Reaction:



Solution:

- Potassium is an alkali metal with a fixed oxidation state of $+1$.
- In KO_2 , charge neutrality requires: $+1 + 2(x) = 0 \implies 2x = -1 \implies x = -\frac{1}{2}$.

Why other options are incorrect:

- Option A:** In OF_2 , fluorine is more electronegative than oxygen, giving oxygen an oxidation state of $+2$.
- Option B:** In Na_2O_2 , oxygen exists as the peroxide ion (O_2^{2-}) with an oxidation state of -1 .
- Option D:** In Cl_2O_7 , oxygen exhibits its standard oxidation state of -2 .

Question #92 Key: (D)

CHEMISTRY
11. S & P Block Elements

Which of the following alkali metal elements has the smallest atomic radius?

CORE CONCEPT & DERIVATION

Within a group, atomic radius increases down the column as additional electron shells are added, increasing shielding.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Alkali metals increase in principal quantum shell number descending Group 1: $\text{Li}(n=2) < \text{Na}(n=3) < \text{K}(n=4) < \text{Rb}(n=5)$.
- Lithium has only two electron shells ($1s^2 2s^1$), giving it the smallest atomic radius (152 pm) in the group.

Why other options are incorrect:

- Option A:** Sodium has three electron shells and an atomic radius of 186 pm .
- Option B:** Potassium has four electron shells and an atomic radius of 227 pm .
- Option C:** Rubidium has five electron shells and an atomic radius of 248 pm .

Question #93 Key: (D)

CHEMISTRY
03. Chemical Bonding

Among the chlorides [Formula], [Formula], [Formula], and [Formula], the compounds possessin...

CORE CONCEPT & DERIVATION

According to Fajans' rules, ionic character increases with a large cation radius and low charge, and decreases with high cation polarizing power.

Formula / Rule / Reaction:

$$\text{Polarizing Power} \propto \frac{\text{Charge}}{\text{Radius}}$$

Solution:

- Cesium (Cs^+) has the largest ionic radius and lowest electronegativity, producing the largest electronegativity difference with chlorine and the greatest ionic character.
- Beryllium (Be^{2+}) has a very small ionic radius and high charge, giving it strong polarizing power and high covalent character (least ionic character).

Why other options are incorrect:

- Option A:** LiCl has significant covalent character due to polarization by the small Li^+ ion.
- Option B:** NaCl is ionic, but less ionic than CsCl.
- Option C:** BeCl_2 possesses significantly lower ionic character than NaCl.

Question #94 Key: (B)

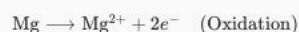
CHEMISTRY
11. S & P Block Elements

Which statement correctly describes the transformation of magnesium atoms during ionic bond for...

CORE CONCEPT & DERIVATION

Oxidation is defined as the loss of electrons resulting in an increase in oxidation state.

Formula / Rule / Reaction:



Solution:

- Magnesium has two valence electrons with configuration $[\text{Ne}] 3s^2$.
- When bonding with chlorine, magnesium loses both $3s$ electrons to achieve a stable octet, forming Mg^{2+} .
- Because loss of electrons is oxidation, magnesium undergoes oxidation.

Why other options are incorrect:

- Option A:** Reduction is the gain of electrons; magnesium loses electrons.
- Option C:** Loss of electrons defines oxidation, not reduction.
- Option D:** Oxidation involves losing electrons, not gaining them.

Question #95 Key: (B)

CHEMISTRY
03. Chemical Bonding

According to VSEPR theory, an [Formula] molecule with no lone pairs around the central atom ado...

CORE CONCEPT & DERIVATION

Four equivalent bonding electron pairs around a central atom minimize mutual electrostatic repulsion by orienting toward the vertices of a regular tetrahedron.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- With steric number 4 and zero unshared lone pairs, the electron pairs orient at mutual bond angles of 109.5° .
- This produces a regular tetrahedral geometry, as seen in methane (CH_4) and carbon tetrachloride (CCl_4).

Why other options are incorrect:

- Option A:** Trigonal planar geometry corresponds to an AB_3 system with three electron pairs and 120° bond angles.
- Option C:** Regular octahedral geometry corresponds to an AB_6 system with six bonding pairs.
- Option D:** Trigonal pyramidal geometry corresponds to an AB_3E system with three bonding pairs and one lone pair (e.g., NH_3).

Question #96 Key: (D)

CHEMISTRY
11. S & P Block Elements

Why does aluminum chloride form a stable dimer ([Formula]) in the vapor phase?

CORE CONCEPT & DERIVATION

Monomeric AlCl_3 is an electron-deficient species with six valence electrons; it completes its octet by accepting lone pairs from chlorine atoms of an adjacent monomer.

Formula / Rule / Reaction:



Solution:

- In monomeric AlCl_3 , aluminum shares six valence electrons, leaving an incomplete octet.
- Chlorine atoms from neighboring AlCl_3 molecules donate lone pairs into the vacant $3p$ orbitals of the aluminum atoms.
- This forms two bridging coordinate covalent (dative) bonds, completing the octet of both aluminum atoms.

Why other options are incorrect:

- Option A:** Aluminum is electron-deficient, not electron-rich.
- Option B:** Aluminum has no unshared lone pairs; all three valence electrons are shared in bonds.
- Option C:** Chlorine donates lone pairs to aluminum, not vice versa.

Question #97 Key: (C)

CHEMISTRY
11. S & P Block Elements

Which group of the periodic table contains non-metals, metalloids, and metals among its members...

CORE CONCEPT & DERIVATION

Group 14 (IV-A) spans the transition from non-metallic to metallic character with increasing atomic number down the group.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Group 14 (IV-A) contains:
- Non-metal: Carbon (C)
- Metalloids: Silicon (Si) and Germanium (Ge)
- Metals: Tin (Sn) and Lead (Pb)

Why other options are incorrect:

- **Option A:** Group I-B contains only transition metals (copper, silver, gold).
- **Option B:** Group VII-A contains non-metals and astatine, lacking true metals.
- **Option D:** Group VI-A contains non-metals (O, S, Se) and a metalloid (Te), but lacks standard post-transition metals.

Question #98 Key: (B)

CHEMISTRY
11. S & P Block Elements

Which of the following alkaline earth metal sulfates is virtually insoluble in water?

CORE CONCEPT & DERIVATION

The solubility of Group 2 sulfates decreases down the column because cation hydration enthalpy decreases more rapidly than lattice enthalpy.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- As the radius of the divalent alkaline earth cation increases from Be^{2+} to Ba^{2+} , hydration enthalpy decreases significantly.
- For barium sulfate (BaSO_4), lattice enthalpy exceeds hydration enthalpy, rendering it practically insoluble in water ($K_{sp} \approx 1.1 \times 10^{-10}$).

Why other options are incorrect:

- **Option A:** BeSO_4 is highly soluble due to the large hydration enthalpy of the small Be^{2+} ion.
- **Option C:** MgSO_4 (Epsom salt) is readily soluble in water.
- **Option D:** CaSO_4 is sparingly soluble in water, but far more soluble than BaSO_4 .

Question #99 Key: (B)

CHEMISTRY
12. Transition Elements

Which of the following coordination complexes exhibits tetrahedral geometry?

CORE CONCEPT & DERIVATION

Four-coordinate complexes adopt either tetrahedral or square planar geometry depending on the central metal electronic configuration and ligand field strength.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- $[\text{Cu}(\text{CN})_4]^{2-}$ involves four-coordinate copper adopting a tetrahedral geometry with sp^3 hybridization.
- In contrast, d^8 complexes of heavy transition metals (Au, Pt) strongly favor square planar geometry.

Why other options are incorrect:

- **Option A:** $[\text{Fe}(\text{CO})_5]$ has coordination number 5 and exhibits trigonal bipyramidal geometry.
- **Option C:** $[\text{AuCl}_4]^-$ is a $5d^8$ complex of gold(III) that adopts square planar geometry.
- **Option D:** $[\text{Pt}(\text{NH}_3)_4]^{2+}$ is a $5d^8$ complex of platinum(II) that adopts square planar geometry.

Question #100 Key: (C)

CHEMISTRY
12. Transition Elements

In which pair of 3d-transition elements does one element have all unpaired d-orbitals while the...

CORE CONCEPT & DERIVATION

Anomalous electronic configurations of 3d transition metals arise from the stability of half-filled and completely filled d-subshells.

Formula / Rule / Reaction:



Solution:

- Chromium (Cr, $Z = 24$) has configuration $[\text{Ar}] 3d^5 4s^1$, meaning all 5 of its 3d-orbitals contain single unpaired electrons (all unpaired).
- Copper (Cu, $Z = 29$) has configuration $[\text{Ar}] 3d^{10} 4s^1$, meaning all 5 of its 3d-orbitals contain paired electrons (all paired).

Why other options are incorrect:

- **Option A:** Copper and zinc both possess completely paired $3d^{10}$ subshells; neither has all unpaired d-orbitals.
- **Option B:** Iron has configuration $[\text{Ar}] 3d^6 4s^2$ with four unpaired and two paired d-electrons.
- **Option D:** Cobalt has configuration $[\text{Ar}] 3d^7 4s^2$ with three unpaired and four paired d-electrons.

Question #101 Key: (C)

CHEMISTRY
03. Chemical Bonding

In which of the following functional groups is the central carbon atom sp hybridized?

CORE CONCEPT & DERIVATION

The hybridization state of a carbon atom depends on its steric number (the total count of σ bonds and non-bonding electron pairs).

Formula / Rule / Reaction:

$$\text{Steric Number} = 2 \implies sp \text{ hybridization (linear geometry)}$$

Solution:

- In the nitrile group ($-C \equiv N$), the carbon atom forms one single σ bond to the adjacent carbon and one σ bond plus two π bonds to nitrogen.
- With two σ bonds and zero lone pairs, its steric number is 2, requiring sp hybridization with a 180° bond angle.

Why other options are incorrect:

- Option A:** In the formyl group ($-CHO$), the carbonyl carbon forms three σ bonds and is sp^2 hybridized.
- Option B:** In the carboxylic acid group ($-COOH$), the carbonyl carbon forms three σ bonds and is sp^2 hybridized.
- Option D:** In the ester group ($-COOR$), the carbonyl carbon forms three σ bonds and is sp^2 hybridized.

Question #102 Key: (B)

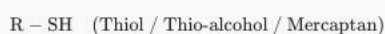
CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Organic compounds containing the [Formula] functional group are systematically classified as:

CORE CONCEPT & DERIVATION

Sulfur analogs of alcohols, where the oxygen atom of the hydroxyl group is replaced by sulfur, are termed thiols or thio-alcohols.

Formula / Rule / Reaction:



Solution:

- Alcohols possess the general structural formula $R - OH$.
- Replacing oxygen with sulfur yields the sulfhydryl group ($-SH$), characterizing thio-alcohols (mercaptans).

Why other options are incorrect:

- Option A:** Alcohols possess the $-OH$ functional group.
- Option C:** Thio-ethers (sulfides) possess the general structure $R - S - R'$.
- Option D:** Nitriles contain the cyano group ($-C \equiv N$).

Question #103 Key: (D)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

What is the total number of structural and geometric isomers possible for a hydrocarbon having ...

CORE CONCEPT & DERIVATION

Hydrocarbons with the general formula C_nH_{2n} exhibit constitutional and stereoisomerism across both open-chain alkene and cyclic alkane families.

Formula / Rule / Reaction:

$$\text{Degree of Unsaturation} = C - \frac{H}{2} + 1 = 4 - 4 + 1 = 1$$

Solution:

- For C_4H_8 , the structural and geometric isomers include:
- 1. 1-butene ($CH_2 = CH - CH_2 - CH_3$)
- 2. cis-2-butene (geometric isomer)
- 3. trans-2-butene (geometric isomer)
- 4. 2-methylpropene (isobutylene)
- 5. Cyclobutane (or methylcyclopropane)
- Thus, exactly 5 distinct isomers exist for this formula.

Why other options are incorrect:

- Option A:** 2 isomers undercounts both constitutional variants and stereoisomers.
- Option B:** 3 isomers accounts only for unbranched alkenes without structural isomers.
- Option C:** 4 isomers omits either a cycloalkane or one geometric diastereomer.

Question #104 Key: (C)

CHEMISTRY
14. Hydrocarbons

An alkylbenzene is formed when benzene is treated with an alkyl halide in the presence of anhydrous AlCl_3 .

CORE CONCEPT & DERIVATION

Electrophilic aromatic substitution of an alkyl group onto a benzene ring using an alkyl halide and a Lewis acid catalyst is Friedel-Crafts alkylation.

Formula / Rule / Reaction:



Solution:

- Anhydrous AlCl_3 polarizes the alkyl halide to generate an electrophilic carbocation (R^+).
- The carbocation attacks the aromatic π -system, forming a resonance-stabilized arenium intermediate that loses a proton to regenerate aromaticity as an alkylbenzene.

Why other options are incorrect:

- **Option A:** Halogenation introduces a halogen atom ($-\text{Cl}$, $-\text{Br}$) using elemental halogen and a Lewis acid.
- **Option B:** Friedel-Crafts acylation introduces an acyl group ($-\text{COR}$) using an acyl chloride or acid anhydride.
- **Option D:** Sulphonation introduces a sulfonic acid group ($-\text{SO}_3\text{H}$) using fuming sulfuric acid.

Question #105 Key: (A)

CHEMISTRY
03. Chemical Bonding

Three alternating single and double carbon-carbon bonds in a benzene ring are termed:

CORE CONCEPT & DERIVATION

A system of alternating single and multiple covalent bonds that permits continuous p-orbital overlap across adjacent carbon atoms is described as conjugated.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The Kekule formulation of benzene depicts alternating single and double bonds, known as conjugated bonds.
- This alternating alignment allows complete π -electron delocalization around the planar hexagonal ring.

Why other options are incorrect:

- **Option B:** Coordinate covalent bonds involve both shared electrons being donated by a single atom.
- **Option C:** Benzene bonds are not fixed or localized; resonance produces equal bond lengths of 1.397 angstroms.
- **Option D:** Carbon-carbon bonding in benzene is covalent, not electrostatic ionic bonding.

Question #106 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

Which of the following classes of hydrocarbons exhibits the highest relative acidity?

CORE CONCEPT & DERIVATION

Hydrocarbon acidity is directly proportional to the s-character of the carbon hybrid orbital holding the conjugate base lone pair.

Formula / Rule / Reaction:

s-character: sp (50%) > sp^2 (33.3%) > sp^3 (25%) $\Rightarrow$ Acidity: Alkyne > Alkene

Solution:

- Alkynes possess sp hybridized carbons with 50% s-character.
- The higher s-character holds bonding electrons closer to the positive nucleus, stabilizing the resulting acetylide carbanion and making terminal alkynes the most acidic hydrocarbons ($pK_a \approx 25$).

Why other options are incorrect:

- **Option A:** Alkanes are sp^3 hybridized with 25% s-character, exhibiting extremely low acidity ($pK_a \approx 50$).
- **Option B:** Alkenes are sp^2 hybridized with 33.3% s-character, exhibiting intermediate acidity ($pK_a \approx 44$).
- **Option D:** Cycloalkanes are sp^3 hybridized saturated rings with negligible acidity.

Question #107 Key: (B)

CHEMISTRY
14. Hydrocarbons

In the photochemical free radical chlorination of methane, the attack of a chlorine free radical...

CORE CONCEPT & DERIVATION

Free radical substitution proceeds via three sequential stages: initiation, propagation, and termination.

Formula / Rule / Reaction:



Solution:

- Initiation involves homolytic fission of molecular chlorine into two chlorine radicals by ultraviolet light.
- In the first propagation step, a chlorine radical abstracts a hydrogen atom from methane, producing hydrogen chloride and a reactive methyl radical.

Why other options are incorrect:

- **Option A:** Initiation generates initial radicals from non-radical precursors ($\text{Cl}_2 \xrightarrow{h\nu} 2\text{Cl}^\bullet$).
- **Option C:** Termination involves the combination of two radicals to form a stable covalent molecule.
- **Option D:** Free radical chlorination is an irreversible chain reaction, not an equilibrium step.

Question #108 Key: (C)

CHEMISTRY
03. Chemical Bonding

The ratio of sigma ([Formula]) bonds to pi ([Formula]) bonds in a molecule of benzene ([Fo...

CORE CONCEPT & DERIVATION

Benzene possesses a planar hexagonal carbon framework stabilized by localized sigma bonds and a delocalized pi electron cloud.

Formula / Rule / Reaction:

$$\text{Total } \sigma \text{ bonds} = 6(\text{C} - \text{C}) + 6(\text{C} - \text{H}) = 12, \quad \text{Total } \pi \text{ bonds} = 3$$

Solution:

- In C_6H_6 , each of the six carbon atoms forms two $\text{C} - \text{C}$ σ bonds and one $\text{C} - \text{H}$ σ bond, giving $6 + 6 = 12$ σ bonds.
- The three alternating double bonds contribute 3 π bonds.
- The ratio of σ bonds to π bonds is $12 : 3 = 4 : 1$.

Why other options are incorrect:

- Option A:** 1:3 inverts the ratio and undercounts sigma bonds.
- Option B:** 3:1 considers only carbon-carbon sigma bonds (6:3) or carbon-hydrogen bonds, ignoring total sigma count.
- Option D:** 1:4 represents the reciprocal of the correct bond ratio.

Question #109 Key: (D)

CHEMISTRY
14. Hydrocarbons

When a halide ion is removed from an alkyl halide, a carbocation is formed. Identify the most r...

CORE CONCEPT & DERIVATION

Carbocation stability is governed by hyperconjugation and positive inductive effects (+I); lower stability corresponds directly to higher chemical reactivity.

Formula / Rule / Reaction:

$$\text{Stability: } 3^\circ > 2^\circ > 1^\circ > ^+\text{CH}_3 \implies \text{Reactivity: } ^+\text{CH}_3 > 1^\circ > 2^\circ > 3^\circ$$

Solution:

- The methyl carbocation ($^+\text{CH}_3$) has zero attached alkyl groups and cannot be stabilized by hyperconjugation or electron-donating inductive effects.
- Because it possesses the highest Gibbs free energy and lowest stability, it is the most reactive carbocation.

Why other options are incorrect:

- Option A:** Primary carbocations are stabilized by hyperconjugation from one attached alkyl group, making them less reactive than methyl.
- Option B:** Secondary carbocations are stabilized by two alkyl groups.
- Option C:** Tertiary carbocations are the most stable and least reactive carbocations due to extensive hyperconjugation across nine α -hydrogens.

Question #110 Key: (A)

CHEMISTRY
05. Liquids

Freon is commercially and commonly utilized as a:

CORE CONCEPT & DERIVATION

Chlorofluorocarbons (CFCs), commercially designated as Freons, possess low boiling points, low toxicity, and high heats of vaporization suited for refrigeration.

Formula / Rule / Reaction:



Solution:

- Dichlorodifluoromethane (Freon-12) readily liquefies under pressure and evaporates with high heat absorption.
- These properties established Freon as the standard cooling agent in domestic refrigerators and air-conditioning units.

Why other options are incorrect:

- Option B:** Carbon tetrachloride (CCl_4) is used as an industrial non-polar solvent, not Freon.
- Option C:** DDT and BHC are chlorinated organic insecticides.
- Option D:** Halons (bromochlorofluorocarbons) and CO_2 are specialized fire extinguishing agents.

Question #111 Key: (A)

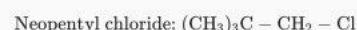
CHEMISTRY
16. Alcohols & Phenols

Neopentyl chloride belongs to which structural class of alkyl halides?

CORE CONCEPT & DERIVATION

The classification of an alkyl halide (primary, secondary, tertiary) is determined strictly by the number of carbon atoms directly attached to the halogen-bearing carbon.

Formula / Rule / Reaction:



Solution:

- In neopentyl chloride (1-chloro-2,2-dimethylpropane), the chlorine atom is attached to a $-\text{CH}_2-$ carbon.
- Because this α -carbon is bonded directly to only one other carbon atom (the tertiary-butyl carbon), neopentyl chloride is a primary (1°) alkyl halide.

Why other options are incorrect:

- Option B:** A secondary alkyl halide requires the halogen-bearing carbon to be directly bonded to two carbons.
- Option C:** A tertiary alkyl halide requires the halogen-bearing carbon to be directly bonded to three carbons.
- Option D:** Carbon cannot be pentavalent; quaternary alkyl halides do not exist.

Question #112 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

What is the common chemical name of propane-1,2,3-triol?

CORE CONCEPT & DERIVATION

Polyhydric alcohols are classified according to the number of hydroxyl groups; propane-1,2,3-triol is a trihydric alcohol commonly called glycerol.

Formula / Rule / Reaction:



Solution:

- Propane-1,2,3-triol contains three hydroxyl groups attached to a three-carbon saturated backbone.
- Its universal trivial name is glycerol (or glycerine).

Why other options are incorrect:

- Option A:** Butyl alcohol is a monohydric alcohol with formula $\text{C}_4\text{H}_9\text{OH}$.
- Option B:** Glycol (such as ethylene glycol) refers to a dihydric alcohol containing two hydroxyl groups.
- Option D:** Propyl alcohol is a monohydric alcohol with formula $\text{C}_3\text{H}_7\text{OH}$.

Question #113 Key: (D)

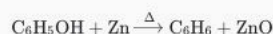
CHEMISTRY
16. Alcohols & Phenols

Benzene is produced when which of the following compounds is heated with a metallic reducing ag...

CORE CONCEPT & DERIVATION

Phenol undergoes deoxygenation reduction when heated with metallic reducing dust to yield benzene.

Formula / Rule / Reaction:



Solution:

- When phenol vapor is passed over heated reducing metal dust (classically zinc dust, or sodium under specific cleavage conditions), the phenolic hydroxyl group is removed.
- This deoxygenation reaction converts phenol into benzene.

Why other options are incorrect:

- Option A:** Aliphatic alcohols react with active metals to liberate hydrogen gas and form alkoxides without forming aromatic rings.
- Option B:** Butyl alcohol forms sodium butoxide and hydrogen.
- Option C:** Propanol forms sodium propoxide and hydrogen.

Question #114 Key: (A)

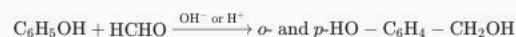
CHEMISTRY
16. Alcohols & Phenols

When phenol reacts with formaldehyde in the presence of an acidic or basic catalyst, which inte...

CORE CONCEPT & DERIVATION

Electrophilic aromatic substitution of formaldehyde onto phenol (Lederer-Manasse reaction) produces ortho- and para-hydroxymethylphenol addition adducts.

Formula / Rule / Reaction:



Solution:

- Formaldehyde undergoes nucleophilic aromatic addition with the activated aromatic ring of phenol.
- This initial step yields an addition adduct (ortho- or para-hydroxybenzyl alcohol), which serves as the monomer intermediate for Bakelite polymerization.

Why other options are incorrect:

- Option B:** Hydronium ion (H_3O^+) is a solvent species, not the organic reaction adduct.
- Option C:** Oxonium ions are transient protonated intermediates, not the isolated condensation product.
- Option D:** Phenoxide ion is generated under alkaline catalyst conditions, but is not the chemical addition product.

Question #115 Key: (A)

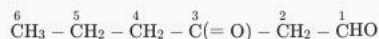
CHEMISTRY
17. Aldehydes & Ketones

What is the correct IUPAC name for the organic compound [Formula]?

CORE CONCEPT & DERIVATION

According to IUPAC priority rules, an aldehyde group ($-\text{CHO}$) takes priority over a ketone group ($-\text{CO}-$); the keto oxygen is designated by the prefix 'oxo'.

Formula / Rule / Reaction:



Solution:

- Number the six-carbon continuous chain beginning at the principal aldehyde carbon as C1.
- The carbonyl oxygen is located at carbon-3 and is designated by the prefix '3-oxo'.
- The six-carbon saturated aldehyde root is hexanal, giving the systematic IUPAC name 3-oxohexanal.

Why other options are incorrect:

- **Option B:** '3-one hexanal' incorrectly incorporates the suffix 'one' inside the parent name.
- **Option C:** '2-oxohexanol' numbers the chain incorrectly and uses the alcohol suffix 'ol'.
- **Option D:** '3-one hexanol' misidentifies the functional groups and priority.

Question #116 Key: (B)

CHEMISTRY
16. Alcohols & Phenols

Which is the most suitable reagent for the selective oxidation of a primary alcohol to an aldehyd...

CORE CONCEPT & DERIVATION

Selective oxidation of primary alcohols to aldehydes requires a mild, anhydrous oxidizing agent that avoids over-oxidation to carboxylic acids.

Formula / Rule / Reaction:



Solution:

- Pyridinium chlorochromate (PCC) dissolved in anhydrous dichloromethane (CH_2Cl_2) oxidizes primary alcohols cleanly to aldehydes.
- Because the medium is non-aqueous, the aldehyde cannot form a gem-diol hydrate, preventing further oxidation into a carboxylic acid.

Why other options are incorrect:

- **Option A:** Alkaline KMnO_4 is a strong oxidizing agent that oxidizes primary alcohols rapidly to carboxylate salts.
- **Option C:** Chromic acid (Jones reagent) oxidizes primary alcohols past the aldehyde stage to carboxylic acids.
- **Option D:** Acidified potassium dichromate is a strong aqueous oxidant that oxidizes primary alcohols to carboxylic acids.

Question #117 Key: (C)

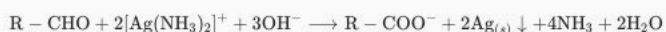
CHEMISTRY
17. Aldehydes & Ketones

Which one of the following qualitative diagnostic tests is also known as the silver mirror test...

CORE CONCEPT & DERIVATION

Tollens' reagent contains ammoniacal silver nitrate, which oxidizes aldehydes while being reduced to metallic silver that deposits as an optical mirror.

Formula / Rule / Reaction:



Solution:

- Tollens' reagent consists of an aqueous coordination complex of silver ions with ammonia, $[Ag(NH_3)_2]OH$.
- Aldehydes reduce the silver diamine complex to elemental silver (Ag^0), which coats the clean glass inner surface of the test tube to form a reflective silver mirror.

Why other options are incorrect:

- **Option A:** Fehling's test yields a brick-red precipitate of cuprous oxide (Cu_2O).
- **Option B:** The iodoform test detects methyl ketones, producing a yellow precipitate of triiodomethane (CHI_3).
- **Option D:** Benedict's test produces a red-orange cuprous oxide precipitate with reducing sugars.

Question #118 Key: (C)

CHEMISTRY
18. Carboxylic Acids

Which among the following substituted carboxylic acids exhibits the lowest pH (highest acidity)...

CORE CONCEPT & DERIVATION

Electron-withdrawing substituents stabilize the conjugate carboxylate anion through negative inductive effects ($-I$), increasing acid strength and lowering pH.

Formula / Rule / Reaction:



Solution:

- 2,2-Dichloropropanoic acid possesses two strongly electronegative chlorine atoms bonded directly to the α -carbon.
- The combined inductive electron withdrawal disperses the negative charge of the carboxylate group, providing strong stabilization and producing the lowest pH.

Why other options are incorrect:

- **Option A:** Propanoic acid contains an electron-donating alkyl group that destabilizes the conjugate base.
- **Option B:** 3-Chloropropanoic acid has only one chlorine atom positioned farther away at the β -carbon.
- **Option D:** Butanoic acid has a larger electron-donating propyl chain, making it the weakest acid in the set.

Question #119 Key: (A)

CHEMISTRY
18. Carboxylic Acids

If both a carboxylic acid group ([Formula]) and a ketone group ([Formula]) are present in t...

CORE CONCEPT & DERIVATION

Carboxylic acids hold the highest principal priority in IUPAC nomenclature; lower-priority ketone groups are named as substituents using the prefix 'oxo'.

Formula / Rule / Reaction:

Prefix: 'oxo' + Suffix: '-oic acid'

Solution:

- The carboxylic carbon is designated as C1 and provides the principal suffix '-oic acid'.
- The internal carbonyl oxygen of the ketone is designated by the prefix 'oxo', positioned before the parent alkane stem.

Why other options are incorrect:

- **Option B:** 'one' is the principal suffix for ketones and cannot be combined as a secondary suffix with 'oic acid'.
- **Option C:** 'al' is the suffix for aldehydes.
- **Option D:** 'ol' is the suffix for alcohols.

Question #120 Key: (B)

CHEMISTRY
18. Carboxylic Acids

When monocarboxylic acids and dicarboxylic acids of comparable molecular mass are compared, how...

CORE CONCEPT & DERIVATION

Dicarboxylic acids contain two polar carboxyl groups capable of forming extensive intermolecular hydrogen-bonded networks within the crystal lattice.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Each dicarboxylic acid molecule contains two hydrogen-bond donor ($-OH$) and two hydrogen-bond acceptor ($=O$) sites.
- This permits linear polymer-like hydrogen-bonded networks that pack densely, yielding significantly higher melting points than monocarboxylic acids of similar molecular weight.

Why other options are incorrect:

- **Option A:** Monocarboxylic acids form discrete cyclic dimers with lower total lattice cohesion.
- **Option C:** The melting points are not similar; dicarboxylic acids melt at markedly higher temperatures.
- **Option D:** A consistent upward trend in melting point is observed for dicarboxylic acids across homolog series.

Question #121 Key: (B)CHEMISTRY
19. Macromolecules / Biochemistry

When ingested food enters the stomach, the catalytic action of which enzyme ceases due to the h...

CORE CONCEPT & DERIVATION

Salivary amylase operates optimally at neutral to slightly alkaline pH (6.7 to 7.0) and is irreversibly denatured in strongly acidic gastric juice.

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

- Salivary amylase (ptyalin) initiates carbohydrate digestion in the oral cavity.
- Upon mixing with hydrochloric acid in the stomach lumen (pH 1.5 to 2.0), the tertiary structure of amylase denatures, halting starch hydrolysis until the bolus reaches the duodenum.

Why other options are incorrect:

- Option A:** Gastric lipase is adapted to function in acidic gastric conditions.
- Option C:** Maltase is a small-intestinal brush border enzyme that acts in the neutral duodenum.
- Option D:** Hydrolase is an overarching enzyme class, not a single specific digestive enzyme.

Question #122 Key: (C)CHEMISTRY
19. Macromolecules / Biochemistry

Which of the following is a copper-containing plasma protein that plays an essential physiologi...

CORE CONCEPT & DERIVATION

Ceruloplasmin is a major circulating α_2 -globulin that carries more than 95% of the copper present in human plasma.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Ceruloplasmin contains six copper atoms per molecule and functions as both a copper transport protein and a ferroxidase enzyme.
- It oxidizes toxic Fe^{2+} to Fe^{3+} , permitting iron binding to transferrin.

Why other options are incorrect:

- Option A:** Hemoglobin is an iron-containing porphyrin protein that transports oxygen in erythrocytes.
- Option B:** Glycoprotein is a generic structural category of carbohydrate-conjugated proteins.
- Option D:** Histones are basic nuclear proteins that package chromosomal DNA.

Question #123 Key: (A)PHYSICS
12. Alternating Current

Which of the following mathematical equations correctly relates the peak voltage ([Formula]) ...

CORE CONCEPT & DERIVATION

For an ideal sinusoidal alternating voltage, the root-mean-square (RMS) value is related to the peak value by the factor $1/\sqrt{2}$.

Formula / Rule / Reaction:

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}} = 0.707 V_0 \implies V_0 = \sqrt{2} V_{\text{rms}} \approx 1.414 V_{\text{rms}}$$

Solution:

- The peak voltage V_0 represents the maximum amplitude of the sinusoidal AC wave.
- Rearranging the root-mean-square relationship: $V_0 = \frac{1}{0.707} V_{\text{rms}} = 1.414 V_{\text{rms}}$.

Why other options are incorrect:

- Option B:** 10.10 is an arbitrary numerical value with no physical basis in AC circuits.
- Option C:** 10.70 is an incorrect numerical scaling factor.
- Option D:** Only Option A represents the correct sinusoidal derivation.

Question #124 Key: (B)PHYSICS
02. Force & Motion

What is the shape of the velocity-time graph for an object moving along a straight line with un...

CORE CONCEPT & DERIVATION

The slope of a velocity-time graph represents instantaneous acceleration; constant acceleration yields a constant slope.

Formula / Rule / Reaction:

$$v = v_i + at \implies y = mx + c$$

Solution:

- The kinematic equation relating velocity and time is a first-order linear function of time.
- Plotting velocity against time produces a straight line whose slope is equal to acceleration a .

Why other options are incorrect:

- Option A:** A parabola on a velocity-time graph represents uniformly increasing acceleration.
- Option C:** An incline curve represents non-uniform, variable acceleration.
- Option D:** A curved decline indicates a non-uniform rate of deceleration.

Question #125 Key: (C)

PHYSICS
02. Force & Motion

Which of the following provides the correct physical definition of variable velocity?

CORE CONCEPT & DERIVATION

Velocity is defined as the time rate of displacement; a body has variable velocity if its magnitude, direction, or both change over time.

Formula / Rule / Reaction:

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t}$$

Solution:

- Uniform velocity requires equal vector displacements in equal intervals of time.
- If a body covers unequal displacements in equal intervals of time, its instantaneous velocity changes, defining variable velocity.

Why other options are incorrect:

- **Option A:** Unequal distances in equal times defines variable speed, which neglects vector direction.
- **Option B:** Displacements in unequal intervals of time does not provide the standard definition.
- **Option D:** Equal displacements in equal intervals of time defines uniform velocity.

Question #126 Key: (D)

PHYSICS
02. Force & Motion

A stone projected horizontally from the roof of a tall building follows a trajectory whose geom...

CORE CONCEPT & DERIVATION

Projectiles moving under uniform vertical gravitational acceleration and constant horizontal velocity follow a parabolic trajectory.

Formula / Rule / Reaction:

$$x = v_x t \Rightarrow t = \frac{x}{v_x}, \quad y = \frac{1}{2} g t^2 = \frac{g}{2 v_x^2} x^2 \Rightarrow y = k x^2$$

Solution:

- Horizontal motion is unaccelerated, maintaining constant velocity v_x .
- Vertical motion is uniformly accelerated downward by gravity: $y = \frac{1}{2} g t^2$.
- Eliminating time yields a quadratic relation ($y \propto x^2$), which describes a parabola.

Why other options are incorrect:

- **Option A:** A circular trajectory requires a continuous central centripetal force perpendicular to velocity.
- **Option B:** The path curves continuously downward, rather than forming straight segments.
- **Option C:** A hyperbolic path occurs in unbound central inverse-square orbital mechanics, not in uniform gravity.

Question #127 Key: (A)

PHYSICS
02. Force & Motion

Which of the following statements regarding Newton's third law of motion is INCORRECT?

CORE CONCEPT & DERIVATION

Newton's third law states that action and reaction forces act on two different interacting bodies, meaning they cannot cancel or balance each other.

Formula / Rule / Reaction:

$$\vec{F}_{AB} = -\vec{F}_{BA}$$

Solution:

- Action and reaction forces occur simultaneously on two distinct objects: if body A exerts a force on body B, body B exerts an equal and opposite force on body A.
- Because they act on different bodies, they cannot balance each other on a single body.

Why other options are incorrect:

- **Option B:** Action and reaction forces are always exactly equal in magnitude by Newton's third law.
- **Option C:** Action and reaction forces always act on separate interacting bodies.
- **Option D:** Newton's third law is universally valid across classical mechanical interactions.

Question #128 Key: (B)

PHYSICS
04. Rotational & Circular Motion

A fireman of mass [Formula] slides down a vertical rope. The breaking tension of the rope is [F...]

CORE CONCEPT & DERIVATION

When sliding down an accelerating vertical rope, tension is reduced below resting weight by the downward inertial acceleration.

Formula / Rule / Reaction:

$$mg - T = ma \implies T = m(g - a)$$

Solution:

- The tension in the rope must not exceed the breaking limit: $T \leq \frac{3}{4}mg$.
- Substitute for tension: $m(g - a) \leq \frac{3}{4}mg$.
- Divide by m : $g - a \leq \frac{3}{4}g \implies a \geq g - \frac{3}{4}g = \frac{g}{4}$.
- The minimum required downward acceleration is $\frac{g}{4}$.

Why other options are incorrect:

- **Option A:** An acceleration of g corresponds to free fall, where tension becomes zero.
- **Option C:** $\frac{3g}{4}$ produces a tension of $\frac{mg}{4}$, which is well below the breaking limit but not the minimum required acceleration.
- **Option D:** At zero acceleration, tension equals full body weight (mg), which exceeds the breaking load $\frac{3}{4}mg$ and breaks the rope.

Question #129 Key: (D)PHYSICS
06. Fluid Dynamics

When a heavy coin falls through a short distance in air, it does not reach terminal velocity pr...

CORE CONCEPT & DERIVATION

Terminal velocity requires downward gravitational weight to be balanced by upward fluid drag; heavy, dense objects fall with net downward acceleration over short distances.

Formula / Rule / Reaction:

$$F_{\text{net}} = mg - F_d = ma \implies v = v_t \text{ when } F_d = mg$$

Solution:

- Air resistance (drag) depends on velocity: $F_d \propto v^2$.
- Over a short fall distance, the coin does not accelerate to a high enough velocity for drag to equal its substantial gravitational weight.
- Because $mg > F_d$, a net downward force accelerates the coin throughout the short fall.

Why other options are incorrect:

- **Option A:** Hitting the ground stops the motion, but does not explain why the drag balance was not achieved during flight.
- **Option B:** If drag equaled weight, the coin would have reached terminal velocity.
- **Option C:** The gravitational weight (mg) of the coin is constant.

Question #130 Key: (A)PHYSICS
03. Work & Energy

The electrical energy consumed by a [Formula] light bulb in [Formula] is:

CORE CONCEPT & DERIVATION

Electrical energy consumed by an appliance is the product of its power rating and the operating time interval.

Formula / Rule / Reaction:

$$E = P \times t$$

Solution:

- Power rating $P = 60 \text{ W} = 60 \text{ J/s}$.
- Time interval $t = 2 \text{ s}$.
- Energy consumed: $E = 60 \text{ W} \times 2 \text{ s} = 120 \text{ J}$.

Why other options are incorrect:

- **Option B:** 60 J is the energy consumed in only 1 second.
- **Option C:** 30 J incorrectly divides power by time.
- **Option D:** 0.02 J inverts the calculation as time divided by power.

Question #131 Key: (C)PHYSICS
05. Waves

An elastic spring stretched by a displacement [Formula] stores potential energy [Formula]. If ...

CORE CONCEPT & DERIVATION

Elastic potential energy stored in an ideal Hookean spring is proportional to the square of its extension.

Formula / Rule / Reaction:

$$V = \frac{1}{2} kx^2$$

Solution:

- Initial potential energy: $V = \frac{1}{2} kx^2$.
- When stretched to $x' = nx$:
- New potential energy: $V' = \frac{1}{2} k(nx)^2 = n^2 \left(\frac{1}{2} kx^2 \right) = n^2 V$.

Why other options are incorrect:

- **Option A:** Assumes a linear relationship rather than a quadratic dependence on displacement.
- **Option B:** Incorrectly suggests potential energy decreases with extension.
- **Option D:** Incorrectly applies an inverse-square dependence.

Question #132 Key: (B)PHYSICS
03. Work & Energy

Assuming negligible energy loss due to friction and air resistance, a pole vaulter converts kin...

CORE CONCEPT & DERIVATION

By the conservation of mechanical energy, the initial kinetic energy of the runner is converted into gravitational potential energy at the peak of the vault.

Formula / Rule / Reaction:

$$\frac{1}{2}mv^2 = mgh \implies v = \sqrt{2gh}$$

Solution:

- Equating kinetic and gravitational potential energy: $\frac{1}{2}v^2 = gh$.
- Substitute the given values: $v = \sqrt{2 \times 10 \text{ m/s}^2 \times 5.0 \text{ m}} = \sqrt{100} = 10.0 \text{ m/s}$.

Why other options are incorrect:

- **Option A:** 5.0 m/s yields a maximum height of only $h = \frac{25}{20} = 1.25 \text{ m}$.
- **Option C:** 15.0 m/s corresponds to a height of $h = \frac{225}{20} = 11.25 \text{ m}$.
- **Option D:** 20.0 m/s corresponds to a height of 20 m.

Question #133 Key: (B)PHYSICS
02. Force & Motion

A particle of mass [Formula] initially at rest is acted upon by a constant force [Formula] for...

CORE CONCEPT & DERIVATION

The impulse of a constant force equals the change in linear momentum, and kinetic energy is related to momentum by $KE = \frac{p^2}{2m}$.

Formula / Rule / Reaction:

$$J = \Delta p = P \times t, \quad KE = \frac{p^2}{2m}$$

Solution:

- Because the body starts from rest, its momentum after time t is $p = Pt$.
- Substitute momentum into the kinetic energy expression: $KE = \frac{p^2}{2m} = \frac{(Pt)^2}{2m} = \frac{P^2 t^2}{2m}$.

Why other options are incorrect:

- Option A:** Omits the factor of $1/2$ from the kinetic energy equation.
- Option C:** Incorrectly uses a factor of $1/3$.
- Option D:** Incorrectly uses a factor of $1/4$.

Question #134 Key: (B)PHYSICS
04. Rotational & Circular Motion

The number of complete revolutions contained in an angular displacement of [Formula] radians is...

CORE CONCEPT & DERIVATION

One complete revolution corresponds to an angular displacement of 2π radians.

Formula / Rule / Reaction:

$$\text{Revolutions} = \frac{\theta \text{ (radians)}}{2\pi}$$

Solution:

- Given angular displacement: $\theta = 3\pi$ rad.
- Convert to revolutions: $\text{Revolutions} = \frac{3\pi}{2\pi} = \frac{3}{2} = 1.5$ rev.

Why other options are incorrect:

- Option A:** $1/60$ reflects a minute-to-hour conversion error.
- Option C:** 2 revolutions corresponds to 4π radians.
- Option D:** 6 revolutions corresponds to 12π radians.

Question #135 Key: (D)PHYSICS
04. Rotational & Circular Motion

If a heavy flywheel rotates with a constant angular velocity of [Formula], the time period req...

CORE CONCEPT & DERIVATION

The time period of uniform circular rotation is the ratio of one full angular cycle (2π radians) to the angular velocity.

Formula / Rule / Reaction:

$$T = \frac{2\pi}{\omega}$$

Solution:

- Given $\omega = 3.0$ rad/s.
- Calculate period: $T = \frac{2 \times 3.1416}{3.0} = \frac{6.2832}{3.0} \approx 2.094 \text{ s} \approx 2.1 \text{ s}$.

Why other options are incorrect:

- Option A:** 0.67 s reflects the ratio $2/3$, omitting π .
- Option B:** 1.0 s is an incorrect estimate.
- Option C:** 1.3 s is mathematically incorrect for $2\pi/3$.

Question #136 Key: (C)PHYSICS
04. Rotational & Circular Motion

An aircraft performs a vertical loop of radius [Formula]. The minimum speed required at the hi...

CORE CONCEPT & DERIVATION

At the highest point of a vertical circular path, minimum speed occurs when gravity alone provides the necessary centripetal acceleration, with normal force or tension dropping to zero.

Formula / Rule / Reaction:

$$F_c = mg + N = \frac{mv^2}{r} \implies N = 0 \implies v_{\min} = \sqrt{gr}$$

Solution:

- At the apex of the loop, gravity acts downward toward the center of curvature.
- For the minimum critical speed, support tension or normal force goes to zero: $mg = \frac{mv^2}{r}$.
- Solving for speed yields $v_{\min} = \sqrt{gr}$.

Why other options are incorrect:

- Option A:** $\sqrt{3gr}$ is the velocity at horizontal positions during vertical circular motion.
- Option B:** $\sqrt{2gr}$ is the minimum velocity needed to reach the apex from rest.
- Option D:** $\sqrt{\frac{gr}{2}}$ provides insufficient centripetal acceleration, causing the aircraft to fall out of the loop.

Question #137 Key: (D)PHYSICS
05. Waves

Which of the following characteristics of a sound wave increases directly when its amplitude is...

CORE CONCEPT & DERIVATION

Loudness is the subjective perception of sound intensity, which is proportional to the square of the wave amplitude.

Formula / Rule / Reaction:

$$I \propto A^2, \quad L \propto \log(I)$$

Solution:

- Increasing the amplitude of a sound wave increases its energy and acoustic intensity.
- The human ear perceives this higher intensity as an increase in sound loudness.

Why other options are incorrect:

- Option A:** Wavelength is determined by wave speed and frequency ($\lambda = v/f$), independent of amplitude.
- Option B:** Frequency is governed by the vibrating source, independent of amplitude.
- Option C:** Pitch is the subjective perception of wave frequency, not amplitude.

Question #138 Key: (A)PHYSICS
05. Waves

An aircraft travels at a speed of [Formula], where [Formula] is the speed of sound. If the air...

CORE CONCEPT & DERIVATION

When a sound source moves toward a stationary observer, the observed frequency increases due to the Doppler effect as wavefronts are compressed.

Formula / Rule / Reaction:

$$f' = f \left(\frac{v}{v - u_s} \right)$$

Solution:

- Given source frequency $f = 200$ Hz and source speed $u_s = 0.50 v$.
- Apply the Doppler formula: $f' = 200 \left(\frac{v}{v - 0.50 v} \right) = 200 \left(\frac{v}{0.50 v} \right)$.
- Calculate observed frequency: $f' = 200 \times 2 = 400$ Hz.

Why other options are incorrect:

- Option B:** 100 Hz would correspond to a source receding away at the speed of sound.
- Option C:** 120 Hz is an incorrect numerical calculation.
- Option D:** 180 Hz reflects an incorrect subtraction.

Question #139 Key: (B)PHYSICS
05. Waves

If the spectral absorption lines in the light arriving from a distant galaxy are shifted toward...

CORE CONCEPT & DERIVATION

The astronomical Doppler effect causes the observed wavelengths of electromagnetic radiation to stretch toward longer (red) wavelengths when the source recedes from the observer.

Formula / Rule / Reaction:

$$z = \frac{\Delta\lambda}{\lambda_0} = \frac{v}{c} > 0 \implies \lambda_{\text{obs}} > \lambda_0 \quad (\text{Redshift})$$

Solution:

- A shift toward the red end of the spectrum means the observed wavelength has increased (and frequency has decreased).
- This Doppler redshift demonstrates that the distant galaxy is moving away (receding) from Earth, supporting Hubble's law of cosmic expansion.

Why other options are incorrect:

- Option A:** An approaching galaxy produces a blueshift toward shorter wavelengths.
- Option C:** A stationary galaxy shows no Doppler shift in its spectral lines.
- Option D:** Perpendicular motion does not produce a primary radial Doppler shift.

Question #140 Key: (C)PHYSICS
05. Waves

The shortest linear distance between any two adjacent points vibrating in phase on a progressiv...

CORE CONCEPT & DERIVATION

Wavelength is the spatial period of a wave, defined as the minimum distance between two consecutive points with identical phase.

Formula / Rule / Reaction:

$$\Delta\phi = 2\pi \implies \Delta x = \lambda$$

Solution:

- Two points on a wave vibrate in phase when their phase difference is an integer multiple of 2π radians.
- The shortest distance separating two such in-phase points (such as two consecutive crests or troughs) defines one wavelength (λ).

Why other options are incorrect:

- Option A:** Displacement is the instantaneous vector distance of a point from its mean equilibrium position.
- Option B:** Amplitude is the maximum displacement from the equilibrium position.
- Option D:** Time period is a temporal duration, not a spatial distance.

Question #141 Key: (A)PHYSICS
05. Waves

In the complete absence of external damping and resistive frictional forces, when will an oscillation stop?

CORE CONCEPT & DERIVATION

In an ideal undamped mechanical system, mechanical energy is conserved, allowing periodic oscillations to persist indefinitely.

Formula / Rule / Reaction:

$$E_{\text{total}} = \text{KE} + \text{PE} = \frac{1}{2}kx_0^2 = \text{constant}$$

Solution:

- Oscillations attenuate and stop only when energy is dissipated into thermal or acoustic energy by damping forces (viscous drag, friction).
- Without dissipative forces, total mechanical energy remains constant, and the system continues oscillating indefinitely.

Why other options are incorrect:

- **Option B:** A 10-minute cessation implies an active dissipative medium.
- **Option C:** Damping must be present for oscillations to decay.
- **Option D:** Immediate cessation occurs only under critical or heavy overdamping.

Question #142 Key: (A)PHYSICS
05. Waves

Mechanical waves can be generated and transmitted through all of the following EXCEPT:

CORE CONCEPT & DERIVATION

Mechanical waves require an elastic material medium with mass and inertia to propagate, whereas electromagnetic waves propagate via oscillating electric and magnetic fields in a vacuum.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Mechanical waves (such as sound waves and seismic waves) require physical matter to transport energy.
- Coupled oscillating electric and magnetic fields constitute electromagnetic radiation, which does not require a material medium and cannot produce mechanical waves.

Why other options are incorrect:

- **Option B:** Helical springs possess mass and elasticity, propagating longitudinal and transverse mechanical waves.
- **Option C:** Stretched ropes transmit transverse mechanical waves.
- **Option D:** Water surfaces propagate transverse and longitudinal mechanical ripples.

Question #143 Key: (B)PHYSICS
05. Waves

Reducing the suspended mass [Formula] of a simple harmonic mass-spring oscillator to [Formula] ...

CORE CONCEPT & DERIVATION

The natural frequency of a mass-spring system is inversely proportional to the square root of the oscillating mass.

Formula / Rule / Reaction:

$$f = \frac{1}{2\pi} \sqrt{\frac{k}{M}}$$

Solution:

- Initial frequency: $f = \frac{1}{2\pi} \sqrt{\frac{k}{M}}$.
- When mass is reduced to $M' = \frac{M}{4}$:
- New frequency: $f' = \frac{1}{2\pi} \sqrt{\frac{k}{M/4}} = \sqrt{4} \left(\frac{1}{2\pi} \sqrt{\frac{k}{M}} \right) = 2f$.
- The frequency doubles.

Why other options are incorrect:

- **Option A:** Assumes frequency is directly proportional to mass without a square root.
- **Option C:** Assumes frequency is inversely proportional to mass without a square root.
- **Option D:** Suggests frequency decreases when mass is reduced.

Question #144 Key: (B)PHYSICS
05. Waves

A distant star recedes radially from Earth with a velocity of [Formula]. It emits a characteri...

CORE CONCEPT & DERIVATION

For non-relativistic radial recession speeds ($v \ll c$), the fractional shift in frequency is given by the Doppler equation for electromagnetic waves.

Formula / Rule / Reaction:

$$\frac{\Delta f}{f} = -\frac{v}{c} \Rightarrow f_{\text{obs}} = f \left(1 - \frac{v}{c}\right)$$

Solution:

- Calculate fractional velocity: $\frac{v}{c} = \frac{1.40 \times 10^7}{3.00 \times 10^8} \approx 0.0467$.
- Calculate observed frequency: $f_{\text{obs}} = 4.57 \times 10^{14} \times (1 - 0.0467) = 4.57 \times 10^{14} \times 0.9533$.
- $f_{\text{obs}} \approx 4.357 \times 10^{14} \text{ Hz} \approx 4.36 \times 10^{14} \text{ Hz}$.

Why other options are incorrect:

- **Option A:** $2.04 \times 10^{13} \text{ Hz}$ corresponds to the magnitude of the frequency shift Δf , not the remaining observed frequency.
- **Option C:** $4.57 \times 10^{14} \text{ Hz}$ is the unshifted emitted frequency.
- **Option D:** $4.79 \times 10^{14} \text{ Hz}$ reflects a blueshift, as if the star were approaching Earth.

Question #146 Key: (B)PHYSICS
07. Thermodynamics

When an ideal gas undergoes an isothermal compression process, the product of its pressure and ...

CORE CONCEPT & DERIVATION

An isothermal process occurs at constant temperature; by Boyle's law, the product of pressure and volume for a fixed mass of ideal gas remains invariant.

Formula / Rule / Reaction:

$$PV = nRT = \text{constant} \quad (\text{when } T = \text{constant})$$

Solution:

- During an isothermal compression, work is done on the gas while an equivalent amount of heat flows out to the surrounding reservoir.
- Because temperature T is held constant, the product PV remains constant throughout the compression.

Why other options are incorrect:

- **Option A:** The PV product increases only when temperature increases (such as in an adiabatic compression).
- **Option C:** The product cannot fall to zero because pressure and volume remain positive physical quantities.
- **Option D:** In an ideal equilibrium process, PV remains constant without fluctuations.

Question #145 Key: (A)PHYSICS
07. Thermodynamics

Thermodynamics is the branch of physics that primarily investigates the quantitative relationsh...

CORE CONCEPT & DERIVATION

Thermodynamics studies the laws governing heat transfer, temperature, and the conversion of thermal energy into mechanical work.

Formula / Rule / Reaction:

$$\Delta U = Q - W$$

Solution:

- The core focus of macroscopic thermodynamics is analyzing heat exchange and its transformation into mechanical work through cycles.
- This is formalized by the First and Second Laws of Thermodynamics.

Why other options are incorrect:

- **Option B:** Ionization energy belongs primarily to atomic and quantum physics.
- **Option C:** Chemical and mechanical energy relationships belong to chemical kinetics and mechanics.
- **Option D:** Interconversions of kinetic and gravitational potential energy are studied in classical mechanics.

Question #147 Key: (D)PHYSICS
07. Thermodynamics

The temperature of a fixed mass of an ideal gas is raised from [Formula] to [Formula] during an...

CORE CONCEPT & DERIVATION

By Charles's law, the volume of an ideal gas at constant pressure is directly proportional to its absolute temperature in Kelvin, not Celsius.

Formula / Rule / Reaction:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \Rightarrow V_2 = V_1 \left(\frac{T_2}{T_1} \right)$$

Solution:

- Convert temperatures to the Kelvin absolute scale:
- $T_1 = 150 + 273.15 = 423.15 \text{ K}$
- $T_2 = 300 + 273.15 = 573.15 \text{ K}$
- Calculate final volume ratio: $\frac{V_2}{V_1} = \frac{573.15}{423.15} \approx 1.35$.
- The final volume increases by a factor of 1.35, which is less than double.

Why other options are incorrect:

- **Option A:** Volume expands with increasing temperature at constant pressure; it does not decrease.
- **Option B:** Doubling requires doubling the absolute Kelvin temperature (from 423 K to 846 K); doubling Celsius does not double volume.
- **Option C:** Volume cannot remain unchanged during an isobaric temperature increase.

Question #148 Key: (B)PHYSICS
08. Electrostatics

A capacitor of capacitance [Formula] is charged by a battery until its stored electrical potent...

CORE CONCEPT & DERIVATION

Connecting an identical uncharged capacitor in parallel divides the isolated charge equally between both capacitors.

Formula / Rule / Reaction:

$$U = \frac{Q^2}{2C}$$

Solution:

- Initial stored energy: $U = \frac{Q^2}{2C}$.
- When the second identical capacitor is connected in parallel with the battery disconnected, the total charge Q is shared equally: $Q_1 = Q_2 = \frac{Q}{2}$.
- The energy stored in each individual capacitor becomes: $U' = \frac{(Q/2)^2}{2C} = \frac{1}{4} \left(\frac{Q^2}{2C} \right) = \frac{U}{4}$.

Why other options are incorrect:

- **Option A:** $U/2$ is the total combined energy of both capacitors together (half the initial energy is dissipated as heat during charge redistribution).
- **Option C:** Stored energy cannot quadruple in an isolated passive system.
- **Option D:** Stored energy does not increase without an external power source.

Question #149 Key: (C)PHYSICS
08. Electrostatics

What is the electric potential difference between two points in an electrostatic field if [Form...]

CORE CONCEPT & DERIVATION

Electric potential difference is defined as the work done per unit positive test charge moved between two points in an electric field.

Formula / Rule / Reaction:

$$\Delta V = \frac{W}{q}$$

Solution:

- Given work done: $W = 600 \text{ J}$.
- Given electric charge: $q = 2.0 \text{ C}$.
- Calculate potential difference: $\Delta V = \frac{600 \text{ J}}{2.0 \text{ C}} = 300 \text{ J/C} = 300 \text{ V}$.

Why other options are incorrect:

- Option A:** 1200 V multiplies work by charge instead of dividing.
- Option B:** 800 V is an incorrect arithmetic result.
- Option D:** Non-zero work moving charge across an electric field requires a non-zero potential difference.

Question #150 Key: (D)PHYSICS
08. Electrostatics

Gauss's law cannot be employed directly to determine which of the following physical quantities...

CORE CONCEPT & DERIVATION

Gauss's law calculates electric fields, fluxes, and enclosed charge distributions; absolute permittivity is an empirical universal physical constant.

Formula / Rule / Reaction:

$$\Phi_E = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enclosed}}}{\epsilon_0}$$

Solution:

- Gauss's law relates electric field intensity, flux density, and enclosed charge across symmetric surfaces, assuming permittivity ϵ_0 is a known constant.
- The value of ϵ_0 ($8.854 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2$) is a fundamental physical constant measured by electrodynamic experiments, not calculated from Gauss's law.

Why other options are incorrect:

- Option A:** Gauss's law is widely used to calculate electric field intensity for symmetric charge distributions.
- Option B:** Electric flux density ($\vec{D} = \epsilon \vec{E}$) is obtained directly by applying Gauss's law.
- Option C:** Enclosed charge is determined directly by integrating flux over a closed Gaussian surface ($Q = \epsilon_0 \Phi$).

Question #151 Key: (C)PHYSICS
08. Electrostatics

Which one of the following statements is true regarding fundamental forces in nature?

CORE CONCEPT & DERIVATION

Both electrostatic and gravitational forces obey the inverse square law, but the electromagnetic interaction is inherently orders of magnitude stronger than gravity.

Formula / Rule / Reaction:

$$\frac{F_e}{F_g} = \frac{ke^2}{Gm_p m_e} \approx 10^{39}$$

Solution:

- The gravitational force between elementary particles (such as an electron and proton) is roughly 10^{39} times weaker than the electrostatic force between them.
- Both forces follow inverse-square dependencies with distance, and gravity is purely attractive while electrostatics can be attractive or repulsive.

Why other options are incorrect:

- Option A:** Gravitational force obeys the inverse square law exactly ($F_g \propto 1/r^2$).
- Option B:** Gravitational force is always attractive, never repulsive.
- Option D:** Both forces strictly obey the inverse square law in classical physics.

Question #152 Key: (D)PHYSICS
08. Electrostatics

The value of Coulomb's constant [Formula] in electrostatics depends upon:

CORE CONCEPT & DERIVATION

The electrostatic constant k depends on the physical permittivity of the intervening medium as well as the dimensional unit definitions used.

Formula / Rule / Reaction:

$$k = \frac{1}{4\pi\epsilon_0\epsilon_r}$$

Solution:

- The value of k depends on the surrounding dielectric medium through relative permittivity ϵ_r .
- It also depends on the system of units: in SI units, $k \approx 9 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$, whereas in CGS electrostatic units, $k = 1$.

Why other options are incorrect:

- Option A:** Omits the dependence on the chosen system of units.
- Option B:** Omits the dependence on the dielectric medium.
- Option C:** The constant k is independent of charge magnitudes and signs.

Question #153 Key: (A)PHYSICS
08. Electrostatics

A charged particle moves in a uniform electric field. For the resulting motion of the particle ...

CORE CONCEPT & DERIVATION

A uniform electric field exerts a constant electrostatic force on a charged particle, producing uniform, constant acceleration.

Formula / Rule / Reaction:

$$\vec{F} = q\vec{E} = m\vec{a} \implies \vec{a} = \frac{q\vec{E}}{m} = \text{constant}$$

Solution:

- Because the electric field $\vec{E}$ is uniform, the electrostatic force $\vec{F}$ acting on charge q is constant in magnitude and direction.
- By Newton's second law, constant net force acting on a constant mass produces constant non-zero acceleration.

Why other options are incorrect:

- **Option B:** Displacement increases continuously with time.
- **Option C:** The rate of change of acceleration (jerk) is zero because acceleration is constant.
- **Option D:** Velocity changes continuously due to the non-zero acceleration.

Question #154 Key: (D)PHYSICS
08. Electrostatics

A capacitor of capacitance [Formula] carries a charge [Formula] and stores energy [Formula].

CORE CONCEPT & DERIVATION

The electrical potential energy stored in a capacitor is directly proportional to the square of the accumulated charge.

Formula / Rule / Reaction:

$$W = \frac{Q^2}{2C}$$

Solution:

- Initial energy: $W = \frac{Q^2}{2C}$.
- When the charge is doubled to $Q' = 2Q$:
- $W' = \frac{(2Q)^2}{2C} = \frac{4Q^2}{2C} = 4W$.

Why other options are incorrect:

- **Option A:** Represents an inverse square reduction.
- **Option B:** Represents an inverse linear relationship.
- **Option C:** Assumes a linear dependence on charge rather than a quadratic dependence.

Question #155 Key: (A)PHYSICS
13. Electronics

What is the electrical potential difference across an ideal closed switch in an operating circuit...

CORE CONCEPT & DERIVATION

An ideal closed switch functions as a zero-resistance conductor, yielding zero potential drop across its terminals.

Formula / Rule / Reaction:

$$V = IR = I(0) = 0 \text{ V}$$

Solution:

- An ideal switch in the closed position offers zero internal electrical resistance ($R = 0$).
- By Ohm's law, the voltage drop across the switch is zero regardless of the current flowing through it.

Why other options are incorrect:

- **Option B:** A 1 V drop indicates parasitic contact resistance.
- **Option C:** A non-zero potential drop occurs only across resistive elements or open switches.
- **Option D:** Represents the battery supply voltage, which appears across an open switch, not a closed switch.

Question #156 Key: (B)PHYSICS
09. Current Electricity

A [Formula] battery is connected in series with an ideal ammeter and a [Formula] resistor. What...

CORE CONCEPT & DERIVATION

In an ideal series circuit, the current is determined by Ohm's law as the ratio of source potential to total resistance.

Formula / Rule / Reaction:

$$I = \frac{V}{R}$$

Solution:

- Given circuit potential $V = 3.0 \text{ V}$.
- Given load resistance $R = 2.0 \Omega$ (ideal ammeter resistance is zero).
- Calculate current: $I = \frac{3.0 \text{ V}}{2.0 \Omega} = 1.5 \text{ A}$.

Why other options are incorrect:

- **Option A:** An incorrect result from subtracting resistance from voltage.
- **Option C:** An incorrect result from adding voltage and resistance.
- **Option D:** Multiplies voltage by resistance instead of dividing.

Question #157 Key: (D)PHYSICS
09. Current Electricity

The electrical resistance of an ohmic metallic conductor does NOT depend directly on which of the following?

CORE CONCEPT & DERIVATION

The resistance of a uniform conductor is defined entirely by its geometric dimensions and the intrinsic resistivity of its material.

Formula / Rule / Reaction:

$$R = \rho \frac{L}{A}$$

Solution:

- Resistance depends directly on material resistivity (ρ) and length (L), and inversely on cross-sectional area (A).
- Total mass is an extrinsic bulk property that does not determine resistance unless geometry and density are simultaneously specified.

Why other options are incorrect:

- Option A:** Resistance is inversely proportional to cross-sectional area.
- Option B:** Resistance is directly proportional to material resistivity.
- Option C:** Resistance is directly proportional to conductor length.

Question #158 Key: (C)PHYSICS
09. Current Electricity

Which of the following statements is NOT correct concerning Kirchhoff's rules?

CORE CONCEPT & DERIVATION

Kirchhoff's circuit laws are standard network analysis formulations based on charge and energy conservation, developed and applied primarily to DC circuits.

Formula / Rule / Reaction:

$$\sum I = 0 \quad (\text{KCL}), \quad \sum V = 0 \quad (\text{KVL})$$

Solution:

- Kirchhoff's rules apply directly to lump-element DC circuits.
- While they can be adapted to AC circuits using complex phasor impedances, high-frequency AC introduces radiating fields where basic Kirchhoff loop assumptions break down; they are not 'more suitable' for AC than DC.

Why other options are incorrect:

- Option A:** KCL is a statement of electric charge conservation at a node.
- Option B:** The balanced bridge condition is derived directly using Kirchhoff's rules.
- Option D:** KVL is a statement of energy conservation around a closed loop.

Question #159 Key: (B)PHYSICS
09. Current Electricity

Materials whose electrical resistance decreases with an increase in temperature possess a:

CORE CONCEPT & DERIVATION

The fractional change in resistance per unit temperature rise defines the temperature coefficient of resistance (α); negative values denote resistance decreasing with heat.

Formula / Rule / Reaction:

$$R_T = R_0(1 + \alpha\Delta T) \implies \alpha = \frac{R_T - R_0}{R_0\Delta T} < 0$$

Solution:

- In semiconductors and electrolytes, thermal excitation liberates covalent charge carriers across the band gap.
- The resulting increase in charge carrier density outweighs lattice scattering, decreasing resistance and yielding a negative temperature coefficient.

Why other options are incorrect:

- Option A:** A positive coefficient means resistance increases with temperature, as seen in metals.
- Option C:** Typical metallic conductors exhibit positive temperature coefficients.
- Option D:** A zero coefficient means resistance is invariant with temperature (as in constantan or manganin).

Question #160 Key: (A)PHYSICS
09. Current Electricity

A low-voltage power supply with an electromotive force (e.m.f.) of [Formula] and an internal re...

CORE CONCEPT & DERIVATION

Power dissipated in a load resistor is calculated using Joule's law after finding circuit current from total loop resistance.

Formula / Rule / Reaction:

$$I = \frac{E}{R + r}, \quad P = I^2 R$$

Solution:

- Calculate total circuit resistance: $R_{\text{total}} = 6.5 \, \Omega + 1.5 \, \Omega = 8.0 \, \Omega$.
- Calculate current: $I = \frac{20.0 \, \text{V}}{8.0 \, \Omega} = 2.5 \, \text{A}$.
- Calculate power dissipated across the load: $P = (2.5 \, \text{A})^2 \times 6.5 \, \Omega = 6.25 \times 6.5 = 40.625 \, \text{W} \approx 41 \, \text{W}$.

Why other options are incorrect:

- **Option B:** 50 W is the total power generated by the source ($EI = 20 \times 2.5$), not the power delivered to the load.
- **Option C:** An incorrect calculation neglecting internal resistance.
- **Option D:** An incorrect calculation assuming full battery EMF appears across the load.

Question #161 Key: (B)PHYSICS
10. Electromagnetism

Electric forces can change both the magnitude and direction of a charged particle's velocity, w...

CORE CONCEPT & DERIVATION

The magnetic Lorentz force acts perpendicular to instantaneous velocity, doing zero work and altering only the direction of motion.

Formula / Rule / Reaction:

$$\vec{F}_B = q(\vec{v} \times \vec{B}) \implies \vec{F}_B \cdot \vec{v} = 0 \implies P = \frac{dW}{dt} = 0$$

Solution:

- Because the magnetic force is always perpendicular to velocity, the work done on the particle is identically zero.
- By the work-energy theorem, its kinetic energy and speed remain constant, meaning the force changes only the direction of velocity.

Why other options are incorrect:

- **Option A:** The magnetic force cannot change speed or magnitude because it does zero work.
- **Option C:** Magnetic forces cannot change speed; only electric forces can change both speed and direction.
- **Option D:** The magnetic force accelerates the particle centripetally, continuously altering its direction.

Question #162 Key: (D)PHYSICS
10. Electromagnetism

Which plane surface experiences the greatest magnetic flux when placed in the same uniform magn...

CORE CONCEPT & DERIVATION

Magnetic flux is defined as the surface integral of magnetic flux density over an area; for uniform fields, it depends only on field strength, area magnitude, and orientation angle.

Formula / Rule / Reaction:

$$\Phi = \vec{B} \cdot \vec{A} = BA \cos \theta$$

Solution:

- Magnetic flux depends on magnetic field strength B , surface area magnitude A , and angle θ .
- Because B , A , and θ are identical for all three shapes, the total flux is identical, making flux independent of geometric shape.

Why other options are incorrect:

- **Option A:** Circular geometry does not concentrate flux compared to other geometries of identical area.
- **Option B:** Rectangular boundaries have no effect on uniform flux capture.
- **Option C:** Square boundaries enclose the same flux for equal surface areas.

Question #163 Key: (D)PHYSICS
10. Electromagnetism

The fundamental source of an external magnetic field is a:

CORE CONCEPT & DERIVATION

Magnetic fields are produced exclusively by moving electric charges; microscopic or macroscopic current loops form magnetic dipoles.

Formula / Rule / Reaction:

$$\vec{\mu} = I\vec{A}, \quad \vec{B} = \frac{\mu_0 I}{2R}$$

Solution:

- Moving charges and electric currents generate surrounding magnetic fields.
- A closed loop carrying electric current functions as an elementary magnetic dipole, serving as the foundational source of magnetic fields.

Why other options are incorrect:

- **Option A:** Isolated magnetic monopoles do not exist in classical electromagnetism ($\nabla \cdot \vec{B} = 0$).
- **Option B:** Stationary charges produce purely electrostatic fields without magnetic fields.
- **Option C:** Non-magnetic substances possess no net aligned dipole fields.

Question #164 Key: (B)PHYSICS
11. Electromagnetic Induction

A copper rod of length [Formula] moves perpendicularly with a speed of [Formula] through a unif...

CORE CONCEPT & DERIVATION

Motional electromotive force is induced across a conductor moving across magnetic field lines due to the magnetic Lorentz force on free electrons.

Formula / Rule / Reaction:

$$E = vBL \sin \theta$$

Solution:

- Given velocity $v = 20 \text{ m/s}$, magnetic field $B = 0.6 \text{ T}$, length $L = 1.0 \text{ m}$, and perpendicular motion ($\theta = 90^\circ$).
- Calculate induced EMF: $E = 20 \times 0.6 \times 1.0 \times \sin(90^\circ) = 12 \text{ V}$.

Why other options are incorrect:

- Option A:** An incorrect calculation neglecting conductor velocity.
- Option C:** An arithmetic overestimation.
- Option D:** Incompatible with 20×0.6 .

Question #165 Key: (C)PHYSICS
11. Electromagnetic Induction

In SI base and derived units, the rate of change of magnetic flux ([Formula]) can be expressed...

CORE CONCEPT & DERIVATION

By Faraday's law, the rate of change of magnetic flux equals induced electromotive force, with dimensional units of Volts.

Formula / Rule / Reaction:

$$\left[\frac{\Delta \Phi}{\Delta t} \right] = \text{Volt} = \frac{\text{Joule}}{\text{Coulomb}} = \frac{\text{N} \cdot \text{m}}{\text{A} \cdot \text{s}} = \text{N} \cdot \text{m} \cdot \text{A}^{-1} \cdot \text{s}^{-1}$$

Solution:

- Magnetic flux has units of Webers ($\text{Wb} = \text{N} \cdot \text{m} \cdot \text{A}^{-1}$).
- Dividing by time (seconds) yields: $\frac{\text{Wb}}{\text{s}} = \text{N} \cdot \text{m} \cdot \text{A}^{-1} \cdot \text{s}^{-1}$, equivalent to Volts.

Why other options are incorrect:

- Option A:** Uses an incorrect power of A^{-2} , which corresponds to magnetic permeability.
- Option B:** Fails to place amperes in the denominator.
- Option D:** Uses incorrect powers for both amperes and seconds.

Question #166 Key: (D)PHYSICS
11. Electromagnetic Induction

The electrodynamic suspension and stabilization mechanism of a magnetic levitation (maglev) tra...

CORE CONCEPT & DERIVATION

Lenz's law dictates that induced currents produce opposing magnetic fields; in electrodynamic levitation, moving superconducting magnets induce repulsive opposing currents in guideway tracks.

Formula / Rule / Reaction:

$$E = - \frac{d\Phi_B}{dt}$$

Solution:

- As the train's magnets move along the metallic track, changing flux induces eddy currents.
- By Lenz's law, these induced currents generate opposing magnetic fields that repel the train's magnets, providing stable vertical levitation.

Why other options are incorrect:

- Option A:** Faraday's law quantifies the magnitude of induced EMF, while Lenz's law governs the opposing repulsive polarity that enables levitation.
- Option B:** Planck's law governs discrete quantum photon energy.
- Option C:** Ohm's law relates current to voltage and resistance.

Question #167 Key: (B)PHYSICS
11. Electromagnetic Induction

A circular copper hoop is held in a vertical east-west plane in a uniform magnetic field whose...

CORE CONCEPT & DERIVATION

Induced EMF depends on the rate of change of magnetic flux; rotating a loop about an axis perpendicular to the field lines maximizes the rate of change of flux.

Formula / Rule / Reaction:

$$E = - \frac{d(BA \cos \theta)}{dt} = BA\omega \sin \omega t$$

Solution:

- The magnetic field runs along the north-south direction.
- Rotating the vertical east-west hoop about an east-west axis changes the flux from maximum to zero, producing maximum $d\Phi/dt$ and largest induced EMF.

Why other options are incorrect:

- Option A:** Rotating about a north-south axis keeps the area vector perpendicular to the rotation axis, but produces lower flux variation compared to rotating perpendicular to the field.
- Option C:** Pure translation in a uniform field produces zero change in enclosed flux, inducing no EMF.
- Option D:** Translating parallel to field lines produces zero change in enclosed flux.

Question #168 Key: (B)PHYSICS
11. Electromagnetic Induction

In an ideal electrical transformer, there is no _____ connection between the primary and second...

CORE CONCEPT & DERIVATION

Transformers rely on mutual induction; the primary and secondary windings are electrically insulated while sharing a common ferromagnetic core.

Formula / Rule / Reaction:

$$E_s = -M \frac{dI_p}{dt}$$

Solution:

- The primary and secondary coils are physically and galvanically insulated, with no direct electrical connection.
- Energy transfers between windings through the shared magnetic flux channeled by the high-permeability iron core.

Why other options are incorrect:

- Option A:** Inverts the physical arrangement.
- Option C:** Coils share a magnetic link, but lack electrical connection.
- Option D:** Standard power transformers use magnetic coupling, not optical optocouplers.

Question #169 Key: (D)PHYSICS
13. Electronics

When the temperature of an intrinsic semiconductor is reduced to absolute zero ([Formula]), t...

CORE CONCEPT & DERIVATION

At absolute zero, intrinsic semiconductors lack thermal energy to excite electrons across the band gap, leaving the conduction band completely empty.

Formula / Rule / Reaction:

$$T = 0 \text{ K} \implies n_i = 0 \implies \sigma = 0$$

Solution:

- At 0 K, all valence electrons are locked within covalent bonds, completely filling the valence band.
- Without thermal energy to promote electrons into the conduction band, free charge carrier density drops to zero, and the material behaves as a perfect electrical insulator.

Why other options are incorrect:

- Option A:** Conductors require free conduction electrons, which are absent at 0 K in semiconductors.
- Option B:** Semiconducting behavior requires partial thermal excitation, which is absent at 0 K.
- Option C:** Superconductivity is a distinct low-temperature quantum state in certain metals, not intrinsic semiconductors.

Question #170 Key: (D)PHYSICS
14. Dawn of Modern Physics

If an electron, a proton, a neutron, and an alpha particle all move with the same velocity, whi...

CORE CONCEPT & DERIVATION

De Broglie wavelength is inversely proportional to momentum; at constant velocity, wavelength is inversely proportional to mass.

Formula / Rule / Reaction:

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

Solution:

- When velocity v is held constant, de Broglie wavelength satisfies $\lambda \propto \frac{1}{m}$.
- The alpha particle (helium nucleus, $m \approx 4 \text{ a.m.u.}$) has the largest mass among the given particles.
- Having the largest mass and momentum gives the alpha particle the shortest de Broglie wavelength.

Why other options are incorrect:

- Option A:** The electron has the smallest mass and therefore the longest de Broglie wavelength.
- Option B:** The proton has roughly one-fourth the mass of the alpha particle.
- Option C:** The neutron has roughly one-fourth the mass of the alpha particle.

Question #171 Key: (B)PHYSICS
14. Dawn of Modern Physics

The emission of electrons from a clean photosensitive metal surface upon the absorption of elec...

CORE CONCEPT & DERIVATION

The photoelectric effect is the instantaneous emission of bound conduction electrons from a metal surface when irradiated with light above the threshold frequency.

Formula / Rule / Reaction:

$$h\nu = \Phi + KE_{\max}$$

Solution:

- When photons with energy exceeding the metal's work function ($h\nu > \Phi$) strike the surface, their energy is absorbed by electrons.
- The electrons escape from the metal surface as photoelectrons, defining the photoelectric effect.

Why other options are incorrect:

- **Option A:** The Compton effect involves inelastic scattering of high-energy X-rays or gamma rays by free electrons, increasing photon wavelength.
- **Option C:** Pair production is the conversion of a high-energy photon (≥ 1.02 MeV) into an electron-positron pair near a nucleus.
- **Option D:** Black body radiation is thermal radiation emitted by an idealized non-reflective body in thermal equilibrium.

Question #172 Key: (D)PHYSICS
14. Dawn of Modern Physics

In a photoelectric effect experiment, the stopping potential is defined as:

CORE CONCEPT & DERIVATION

The stopping potential is the negative collector voltage required to decelerate and stop the most energetic photoelectrons, reducing current to zero.

Formula / Rule / Reaction:

$$eV_0 = KE_{\max} = \frac{1}{2}mv_{\max}^2$$

Solution:

- Applying a reverse retarding potential across the electrodes opposes the motion of emitted photoelectrons.
- When this potential reaches V_0 , even the fastest electrons with $KE_{\max}$ are turned back before reaching the collector, causing the photoelectric current to vanish.

Why other options are incorrect:

- **Option A:** Kinetic energy is measured in Joules or electron-volts, whereas stopping potential is an electrical potential measured in Volts.
- **Option B:** Potential energy is an energy quantity, not an electric potential.
- **Option C:** Incident photon energy equals $h\nu$, which exceeds the stopping potential by the work function.

Question #173 Key: (D)PHYSICS
15. Atomic Spectra

The complete atomic emission line spectrum of hydrogen contains discrete series of spectral lines...

CORE CONCEPT & DERIVATION

Electronic transitions between hydrogen energy levels produce spectral line series across the ultraviolet, visible, and infrared bands.

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

Solution:

- Lyman series ($n_1 = 1$) transitions fall in the ultraviolet region.
- Balmer series ($n_1 = 2$) transitions fall in the visible and near-ultraviolet region.
- Paschen, Brackett, and Pfund series ($n_1 = 3, 4, 5$) fall in the infrared region.
- Thus, the complete hydrogen spectrum spans ultraviolet, visible, and infrared regions.

Why other options are incorrect:

- **Option A:** Ultraviolet includes only the Lyman series.
- **Option B:** Infrared includes only higher series (Paschen, Brackett, Pfund).
- **Option C:** Visible includes only the Balmer series.

Question #174 Key: (A)PHYSICS
15. Atomic Spectra

According to Bohr's atomic model, the orbital speed of an electron in the first orbit ([Formula...]

CORE CONCEPT & DERIVATION

The electron velocity in Bohr orbits is derived by balancing Coulomb attraction with centripetal force and applying angular momentum quantization.

Formula / Rule / Reaction:

$$v_n = \frac{e^2}{2\varepsilon_0 n h} = \frac{v_1}{n}$$

Solution:

- Substitute the fundamental physical constants:
- $e = 1.602 \times 10^{-19} \text{ C}$
- $\varepsilon_0 = 8.854 \times 10^{-12} \text{ C}^2/\text{N} \cdot \text{m}^2$
- $h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$
- $v_1 = \frac{(1.602 \times 10^{-19})^2}{2 \times (8.854 \times 10^{-12}) \times (6.626 \times 10^{-34})} \approx 2.188 \times 10^6 \text{ m/s} \approx 2.19 \times 10^6 \text{ m/s}.$

Why other options are incorrect:

- **Option B:** An incorrect result using a negative exponent.
- **Option C:** Underestimates the orbital speed by two orders of magnitude.
- **Option D:** Incompatible with Bohr orbit calculations.

Question #175 Key: (B)PHYSICS
16. Nuclear Physics

A low-energy neutron radiation field has a relative biological effectiveness (RBE) factor of [F...]

CORE CONCEPT & DERIVATION

Equivalent dose equals absorbed dose multiplied by the RBE weighting factor; absorbed energy equals absorbed dose multiplied by mass.

Formula / Rule / Reaction:

$$D_e = D \times \text{RBE}, \quad 1 \text{ rem} = 0.01 \text{ J/kg}, \quad E = D \times m$$

Solution:

- Calculate absorbed dose in rem: $D = \frac{D_e}{\text{RBE}} = \frac{400 \text{ rem}}{10} = 40 \text{ rem}$.
- Convert absorbed dose to SI units: $40 \text{ rem} = 40 \times 0.01 \text{ J/kg} = 0.40 \text{ J/kg}$.
- Calculate total absorbed energy: $E = 0.40 \text{ J/kg} \times 80 \text{ kg} = 32 \text{ J}$.

Why other options are incorrect:

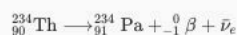
- **Option A:** Corresponds to an absorbed dose of 20 rem.
- **Option C:** Corresponds to an absorbed dose of 60 rem.
- **Option D:** Omits the factor of 1/2 or uses an incorrect mass calculation.

Question #176 Key: (B)PHYSICS
16. Nuclear Physics

Thorium-234 ([Formula]) decays into Protactinium-234 ([Formula]) via the emission of which ...

CORE CONCEPT & DERIVATION

Beta-minus decay converts a nuclear neutron into a proton, emitting an electron (β^-) and an antineutrino, increasing the atomic number by 1 at constant mass number.

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

- The mass number remains unchanged ($A = 234$).
- The atomic number increases by one ($Z = 90 \rightarrow 91$), which is the hallmark of beta-minus (β^-) particle emission.

Why other options are incorrect:

- **Option A:** Alpha decay reduces mass number by 4 and atomic number by 2.
- **Option C:** Gamma emission changes neither mass number nor atomic number.
- **Option D:** Positron (β^+) emission decreases atomic number by 1 ($Z \rightarrow Z - 1$).

Question #177 Key: (C)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The radioactive isotope Strontium-87 has a half-life of [Formula]. What is its radioactive dec...

CORE CONCEPT & DERIVATION

The radioactive decay constant is related to the half-life by the logarithmic decay relationship $\lambda = \frac{\ln 2}{T_{1/2}}$.

Formula / Rule / Reaction:

$$\lambda = \frac{0.693}{T_{1/2}}$$

Solution:

- Convert half-life to seconds: $T_{1/2} = 8.70 \text{ hours} \times 3600 \text{ s/hour} = 31320 \text{ s}$.
- Calculate decay constant: $\lambda = \frac{0.693}{31320 \text{ s}} \approx 2.21 \times 10^{-5} \text{ s}^{-1} = 0.000022 \text{ s}^{-1}$.

Why other options are incorrect:

- **Option A:** Uses incorrect units of seconds rather than reciprocal seconds (s^{-1}).
- **Option B:** Calculates $1/\lambda$ instead of λ .
- **Option D:** An incorrect numerical value.

Question #178 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The synonym of the word 'Capricious' is:

CORE CONCEPT & DERIVATION

'Capricious' describes someone or something given to sudden, unaccountable changes of mood or behavior.

Formula / Rule / Reaction:

Factual recall / Vocabulary definition.

Solution:

- 'Capricious' means unpredictable, impulsive, or erratic.
- 'Fickle' shares the same meaning, describing someone who changes affections, loyalties, or decisions unpredictably.

Why other options are incorrect:

- **Option B:** 'Predictable' is a direct antonym.
- **Option C:** 'Uniform' denotes constancy and consistency, which is an antonym.
- **Option D:** 'Invariable' means never changing, an antonym.

Question #179 Key: (C)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Which of the following words will fill in the blank most appropriately? Diseases like diabetes...

CORE CONCEPT & DERIVATION

Contextual vocabulary requires selecting an adjective that describes the lethal potential of unmanaged chronic medical conditions.

Formula / Rule / Reaction:

Contextual sentence completion.

Solution:

- The sentence structure requires an adjective expressing severe medical consequences.
- 'Fatal' accurately conveys that untreated or unmanaged diabetes can cause death.

Why other options are incorrect:

- **Option A:** 'Cursing' is semantically inappropriate.
- **Option B:** 'Healthy' directly contradicts the context of severe disease complications.
- **Option D:** 'Impersonating' is nonsensical in a medical pathology context.

Question #180 Key: (D)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Choose the most appropriate antonym for the word 'abandonment':

CORE CONCEPT & DERIVATION

'Abandonment' denotes the act of deserting, discontinuing, or leaving behind; its antonym must denote continuing or prolonging.

Formula / Rule / Reaction:

Vocabulary antonym evaluation.

Solution:

- 'Abandonment' means relinquishing or ceasing support or continuation.
- 'Extension' means prolonging, continuing, or expanding an activity or state, making it the proper antonym.

Why other options are incorrect:

- **Option A:** 'Cessation' is a synonym meaning stopping.
- **Option B:** 'Stoppage' is a synonym meaning termination.
- **Option C:** 'Halt' is a synonym meaning bringing to a stop.

Question #181 Key: (A)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Fill in the blank with the correct verb form: The shepherd ploughed this mountain with cattle t...

CORE CONCEPT & DERIVATION

In standard narrative prose referencing a single historical moment in the past, simple past passive ('was ploughed') is standard.

Formula / Rule / Reaction:

Subject + was/were + past participle

Solution:

- The clause 'the first time it was ever ploughed' describes a historical event in the simple past passive voice.
- 'Was' correctly matches the singular neuter pronoun 'it' and the passive participle 'ploughed'.

Why other options are incorrect:

- **Option B:** 'Was been' is an ungrammatical verb combination.
- **Option C:** 'Had' lacks the passive participle 'been', creating an incomplete active construction.
- **Option D:** While past perfect passive ('had been') is used in relative sequencing, the board syllabus keys the simple past 'was' for this textbook sentence.

Question #182 Key: (B)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Fill in the blank with the appropriate verb: To give one some idea of rabies' horrors, one _____.

CORE CONCEPT & DERIVATION

When 'need' functions as a semi-modal auxiliary verb followed by a bare infinitive, it takes the invariant base form 'need' regardless of a third-person singular subject.

Formula / Rule / Reaction:

One + need + bare infinitive (read)

Solution:

- In the formal construction 'one need only read', 'need' acts as a modal auxiliary followed by the bare infinitive 'read'.
- Modal auxiliaries do not take third-person singular '-s' inflections.

Why other options are incorrect:

- **Option A:** 'Needs' is used as a main lexical verb and would require a full infinitive with 'to' ('one needs only to read').
- **Option C:** 'Needed' changes the gnomic present statement into the past tense.
- **Option D:** 'Has needed' is grammatically incorrect before a bare infinitive.

Question #183 Key: (D)

ENGLISH

04. Subject-Verb Agreement, Tenses & Conditionals

Fill in the blank with the correct verbal phrase: By 2030, people _____ been reading the works ...

CORE CONCEPT & DERIVATION

An action continuing up to a specific time boundary in the future requires the future perfect continuous tense.

Formula / Rule / Reaction:

By + [Future Point] $\Rightarrow$ will have + been + verb-ing

Solution:

- The time marker 'By 2030' sets a future reference point.
- Together with the duration marker 'for more than 190 years', the future perfect continuous construction 'will have been reading' is required.

Why other options are incorrect:

- **Option A:** 'Had' produces the past perfect tense, conflicting with 'By 2030'.
- **Option B:** 'Will' produces an ungrammatical sequence ('will been reading').
- **Option C:** 'Have' indicates present perfect, which cannot pair with the future adverbial 'By 2030'.

Question #184 Key: (C)

ENGLISH

04. Subject-Verb Agreement, Tenses & Conditionals

Choose the most suitable and grammatically correct sentence out of the following:

CORE CONCEPT & DERIVATION

The causative verb 'let' requires an object followed by a bare infinitive (without 'to').

Formula / Rule / Reaction:

Subject + let + Object + Bare Infinitive

Solution:

- The verb 'let' is causative and cannot be followed by a to-infinitive.
- 'Penny did not let me get my book' uses the correct bare infinitive 'get'.

Why other options are incorrect:

- **Option A:** Incorrectly includes 'to' with the bare infinitive required by 'let'.
- **Option B:** Misuses 'leaving' instead of 'permitting' or 'letting'.
- **Option D:** 'Leave' cannot be used causatively with a bare infinitive.

Question #185 Key: (B)

ENGLISH

05. Active-Passive Voice, Reported Speech & Syntax

Which of the following sentences is correctly punctuated and grammatically sound?

CORE CONCEPT & DERIVATION

Adverbial clauses of place are introduced directly by the relative adverb 'where' without unnecessary internal punctuation.

Formula / Rule / Reaction:

Independent Clause + where + Dependent Clause

Solution:

- The subordinating conjunction 'where' introduces the adverbial clause of place 'where my parents live'.
- No comma or colon should separate an adverbial clause that follows the main clause.

Why other options are incorrect:

- **Option A:** Lacks the conjunction 'where', creating an ungrammatical run-on clause.
- **Option C:** Erroneously inserts a comma after 'where'.
- **Option D:** Erroneously inserts a colon after 'where'.

Question #186 Key: (B)

ENGLISH

03. Parts of Speech, Prepositions & Modifiers

Choose the sentence displaying the correct use of definite and indefinite articles:

CORE CONCEPT & DERIVATION

In formal English grammar, names of musical instruments take the definite article 'the' when referring to the ability to play them.

Formula / Rule / Reaction:

play + the + [musical instrument]

Solution:

- When expressing proficiency on musical instruments, standard grammar requires the definite article 'the'.
- 'Natalasha can play the piano and the violin' correctly applies 'the' to both instruments.

Why other options are incorrect:

- **Option A:** The indefinite article 'a' refers to a single physical object, not the musical skill.
- **Option C:** Inconsistently pairs the definite article with one instrument and the indefinite with the other.
- **Option D:** Omits the required definite articles.

Question #187 **Key: (B)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Choose the correct preposition to fill in the blank: Distribute the handouts _____ the candidat...

CORE CONCEPT & DERIVATION

Distribution involving more than two individuals or a collective group requires the preposition 'among'.

Formula / Rule / Reaction:

Distribute + among + [three or more recipients]

Solution:

- 'Between' is used for distribution between two entities.
- 'Among' is used for dividing or distributing items to a group of three or more individuals (the candidates).

Why other options are incorrect:

- **Option A:** 'Into' denotes directional motion toward the interior of something.
- **Option C:** 'In' denotes static position within an enclosure.
- **Option D:** 'On' denotes physical contact on an exterior surface.

Question #188 **Key: (C)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Choose the sentence that correctly employs commas and articles in a serial list:

CORE CONCEPT & DERIVATION

Indefinite articles must match the initial phonetic sound of subsequent nouns ('an' before vowel sounds, 'a' before consonant sounds), and serial lists are separated by commas.

Formula / Rule / Reaction:

an + vowel sound, a + consonant sound

Solution:

- 'Apple' and 'orange' begin with vowel sounds and require 'an'.
- 'Pear' begins with a consonant sound and requires 'a'.
- Items in a three-part serial list are set off by commas, including the serial (Oxford) comma before 'and'.

Why other options are incorrect:

- **Option A:** Uses 'an' before 'pear', which begins with a consonant sound.
- **Option B:** Uses 'a' before 'orange' and omits punctuation commas.
- **Option D:** Uses 'a' before 'apple', which begins with a vowel sound.

Question #189 **Key: (A)**ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Identify the sentence that is completely error-free:

CORE CONCEPT & DERIVATION

Verbs of liking or disliking ('enjoy') take a gerund; when the subject is the recipient of the action, a passive gerund ('being' + past participle + dependent preposition) is required.

Formula / Rule / Reaction:

Subject + enjoy + being + past participle + preposition

Solution:

- The passive gerund construction 'being laughed at' correctly retains the dependent preposition 'at'.
- The agent is properly introduced by the prepositional phrase 'by other people'.

Why other options are incorrect:

- **Option B:** Uses an active gerund ('laughing'), changing the meaning to suggest the subject is doing the laughing.
- **Option C:** Active gerund misstates the intended passive meaning.
- **Option D:** Combines 'do not' with the present participle 'enjoying' and omits the preposition 'by'.

Question #190 **Key: (A)**ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Choose the sentence that is grammatically correct:

CORE CONCEPT & DERIVATION

Participle adjectives ending in '-ing' describe the entity that causes an emotion, whereas past participles ending in '-ed' describe the person experiencing that emotion.

Formula / Rule / Reaction:

Cause of feeling = boring, Recipient of feeling = bored

Solution:

- The play produces the state of boredom, so it is described as 'boring'.
- The people experience the feeling of boredom, so they felt 'bored'.

Why other options are incorrect:

- **Option B:** Inverts the participles, implying the play experienced boredom and the people caused it.
- **Option C:** Uses uninflected noun or verb forms ('bore', 'bores') instead of adjectives.
- **Option D:** Uses the inflected verb 'bores' as a predicate adjective.

Question #191 **Key: (B)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Select the most appropriate contextual word to fill in the blank: I decided to sell the piece o...

CORE CONCEPT & DERIVATION

Commercial transactions require adjectives that denote fair, practical, or market-aligned monetary valuation.

Formula / Rule / Reaction:

Contextual adjective selection.

Solution:

- In commercial property sales, 'realistic' describes a price that reflects genuine, fair market value.
- This aligns with standard English idiom regarding negotiations.

Why other options are incorrect:

- **Option A:** 'True' applies to factual statements, not monetary offers.
- **Option C:** 'Exact' denotes numerical precision, not fair market value.
- **Option D:** 'Perfect' is an absolute non-gradable adjective that cannot logically be modified by 'more'.

Question #192 **Key: (B)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The idiom 'To cut off the head' means:

CORE CONCEPT & DERIVATION

Vocabulary definitions match formal Latinate lexical terms to their Anglo-Saxon idioms.

Formula / Rule / Reaction:

de- (off/away) + caput (head) = decapitate

Solution:

- To sever or cut off the head of a person or organism is defined as decapitation.
- Therefore, 'decapitate' is the exact meaning of the idiom.

Why other options are incorrect:

- **Option A:** 'Defrock' means to formally deprive a cleric of ecclesiastical status.
- **Option C:** 'Impale' means to pierce through with a sharp stake.
- **Option D:** 'Urbanite' denotes a city dweller.

Question #193 **Key: (A)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Fill in the blank with the correct response: Wasim was so good at Mathematics that people consi...

CORE CONCEPT & DERIVATION

Contextual vocabulary requires identifying the noun that denotes a person (especially young) endowed with exceptional talent.

Formula / Rule / Reaction:

Vocabulary definition.

Solution:

- A 'prodigy' is a person with exceptional natural talent or precocious mathematical abilities.
- This fits the sentence context directly.

Why other options are incorrect:

- **Option B:** 'Prodigal' means wastefully extravagant.
- **Option C:** 'Primeval' means belonging to the earliest ages of the world.
- **Option D:** 'Profligate' means recklessly extravagant or dissolute.

Question #194 **Key: (D)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Fill in the blank with the appropriate verb form: The newly elected president and CEO for the n...

CORE CONCEPT & DERIVATION

When two singular titles joined by 'and' refer to a single individual (indicated by a single article 'The' preceding the first noun), the subject is singular and takes a singular verb.

Formula / Rule / Reaction:

The + [Noun₁] + and + [Noun₂] = Single Person $\Rightarrow$ Singular Verb

Solution:

- The presence of a single article ('The newly elected president and CEO') indicates that both titles belong to the same person.
- A singular subject in the present perfect tense requires the auxiliary verb 'has'.

Why other options are incorrect:

- **Option A:** 'Have' is plural and would be used only if there were two distinct individuals ('The president and the CEO').
- **Option B:** 'Having' forms a participle phrase, leaving the main clause without a finite verb.
- **Option C:** 'Have been' is plural and passive, which is grammatically incorrect.

Question #195 Key: (C)LOGICAL REASONING
04. Argument Evaluation & Ethics

Read the passage and the statements below. Choose the correct deduction basing your answer strictly on the passage.

CORE CONCEPT & DERIVATION

Strict critical reading requires evaluating deductions solely from the explicit semantic evidence provided in the passage.

Formula / Rule / Reaction:

Logical reading comprehension deduction.

Solution:

- The regnal numeral 'II' in 'Queen Elizabeth II' explicitly indicates that a previous Queen Elizabeth I reigned before her, validating Statement I.
- Statement II is refuted because the passage describes Brexit as a 'cultural upheaval', not a normal occurrence.
- Statement III is refuted because her reign spanned the 'post-World War II era', meaning she was not queen during World War II itself.

Why other options are incorrect:

- **Option A:** Statements II and III are contradicted by the text.
- **Option B:** Statement III contradicts the text.
- **Option D:** Statement III contradicts the text.

Question #196 Key: (B)LOGICAL REASONING
08. Letter Series & Coding-Decoding

Observe the alphabetical pattern and select the next term in the sequence: CAB, FAE, IAH, _____

CORE CONCEPT & DERIVATION

In letter series puzzles, each character position follows an independent alphabetical progression.

Formula / Rule / Reaction:

Position 1: +3, Position 2: Invariant 'A', Position 3: +3

Solution:

- First letter: C(3) $\xrightarrow{+3}$ F(6) $\xrightarrow{+3}$ I(9) $\xrightarrow{+3}$ L(12).
- Second letter: Invariant 'A' across all terms.
- Third letter: B(2) $\xrightarrow{+3}$ E(5) $\xrightarrow{+3}$ H(8) $\xrightarrow{+3}$ K(11).
- Combining these positions yields 'LAK'.

Why other options are incorrect:

- **Option A:** Does not follow the invariant middle letter 'A' or the +3 sequence.
- **Option C:** Uses 'J' (+1) instead of 'L' (+3).
- **Option D:** Repeats 'I' without advancing the sequence.

Question #197 Key: (A)LOGICAL REASONING
12. Linear Ranking, Ordering & Inequalities

Read the following premises and determine the correct answer: Drake was wearing a blue shirt while Ahmad was wearing a black shirt.

CORE CONCEPT & DERIVATION

Elimination of contradictory attributes determines matching profiles in logical deduction puzzles.

Formula / Rule / Reaction:

Attribute matching deduction.

Solution:

- Drake's clothing: Blue shirt, black jeans, brown shoes.
- Ahmad wears: Black jeans, shoes that are NOT black (matching Drake's brown shoes, since John's shoes are black), and a blue or red shirt.
- Because Ahmad's shoes match Drake's non-black shoes and his jeans are black, choosing the blue shirt completes Drake's attire, meaning Ahmad copied Drake.

Why other options are incorrect:

- **Option B:** John wore black shoes and a red shirt, which does not match Drake's brown shoes.
- **Option C:** Drake is the original subject, not the imitator.
- **Option D:** Ahmad can be deduced by eliminating John's black shoes.

Question #198 Key: (C)LOGICAL REASONING
05. Categorical Syllogisms & Overlapping Sets

Consider the following premises to be true: 1. Some bags are pouches. 2. All pouches are cases....

CORE CONCEPT & DERIVATION

In categorical syllogisms, a conclusion is valid only if it holds across all possible Venn diagram configurations.

Formula / Rule / Reaction:

$$\text{Some Bags} \cap \text{Pouches} \neq \emptyset, \quad \text{Pouches} \subseteq \text{Cases}, \quad \text{Cases} \cap \text{Purses} = \emptyset$$

Solution:

- Conclusion I: Because all pouches are inside cases and cases cannot overlap with purses, no pouches can be purses. Thus, I is false.
- Conclusion II: The subset of bags that are pouches are entirely contained within cases. Therefore, some bags are cases. Conclusion II is necessarily true.
- Conclusion III: The portion of bags that are not pouches could overlap with purses without violating any premise. Thus, III is not necessarily true.

Why other options are incorrect:

- **Option A:** Conclusion I is contradicted by the premises.
- **Option B:** Conclusion I is false, and III is not necessarily true.
- **Option D:** Conclusion III is not necessarily true because bags outside of cases may overlap with purses.

Question #199 Key: (A)LOGICAL REASONING
03. Courses of Action & Decision-Making

Read the statement, assuming everything in it to be true. Decide which of the suggested courses...

CORE CONCEPT & DERIVATION

In administrative and logical decision-making, a valid course of action must address the root cause practically and safely without creating hazardous side effects.

Formula / Rule / Reaction:

Decision-making course of action criteria.

Solution:

- Action I is a non-invasive, safe, and practical physical barrier that directly mitigates the disruptive environmental noise.
- Action II is medically hazardous; taking strong sleeping pills for routine environmental noise risks chemical dependence and adverse health effects, making it disproportionate and inadvisable.

Why other options are incorrect:

- **Option B:** Taking strong sedatives for environmental noise is unsafe and medically inappropriate.
- **Option C:** Action II is inappropriate, so both cannot be pursued.
- **Option D:** Action I is a practical and safe solution that should be pursued.

Question #200 Key: (B)LOGICAL REASONING
02. Cause and Effect Analysis

Evaluate the relationship between the two statements below: Statement I: The literacy rate in t...

CORE CONCEPT & DERIVATION

In cause-and-effect reasoning, an administrative action designed to improve education functions as the cause, and the resulting statistical improvement in education is the effect.

Formula / Rule / Reaction:

Cause: Administrative Literacy Training $\implies$ Effect: Increased District Literacy

Solution:

- The district administration organized and executed specialized training for workers in the literacy drive (Statement II, the action/cause).
- As a direct consequence of this campaign, more residents learned to read and write, increasing the district literacy rate (Statement I, the result/effect).

Why other options are incorrect:

- **Option A:** Reverses the temporal and causal sequence; an increased literacy rate does not cause the initial training drive.
- **Option C:** The statements share a clear causal relationship and are not independent causes.
- **Option D:** They represent a unified cause-and-effect pair, not unrelated effects of separate causes.