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DUHS KARACHI

DUHS Karachi MDCAT 2024 Official Paper

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

🛡️ Official Admitting Board: Dow University of Health Sciences Karachi 📄 Archive Code: BEAMBE-FLP-DUHS-2024

🕒 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

Stimuli such as pressure, touch, stretch, and motion stimulate which of the following sensory receptors?

- (A) Thermoreceptors
- (B) Mechanoreceptors
- (C) Gustatory receptors
- (D) Olfactory receptors

Q2. BIO

The condition where two different alleles of a gene pair are both fully and simultaneously expressed in a heterozygote is called:

- (A) Codominance
- (B) Incomplete dominance
- (C) Epistasis
- (D) Pleiotropy

Q3. BIO

A bacterium with a tuft of flagella present at each of its two poles is classified as:

- (A) Amphitrichous
- (B) Monotrichous
- (C) Lophotrichous
- (D) Peritrichous

Q4. BIO

What is the correct sedimentation order of cellular organelles from lowest to highest centrifugal speed during differential ultracentrifugation?

- (A) Ribosomes → Nuclei → Mitochondria
- (B) Lysosomes → Ribosomes → Mitochondria
- (C) Nuclei → Mitochondria → Ribosomes
- (D) Mitochondria → Nuclei → Ribosomes

Q5. BIO

A peptide hormone released from Sertoli cells that selectively inhibits the secretion of follicle-stimulating hormone (FSH) is:

- (A) Testosterone
- (B) Gonadotropin-releasing hormone
- (C) Luteinizing hormone
- (D) Inhibin

Q6. BIO

Which protein complex stabilizes the separated single strands of DNA during replication to prevent them from reannealing?

- (A) Double-stranded binding proteins
- (B) Single-stranded binding proteins
- (C) DNA ligase
- (D) DNA topoisomerase

Q7. BIO

Which of the following is not an essential requirement for the process of photosynthesis to take place?

- (A) Oxygen
- (B) Chlorophyll
- (C) Carbon dioxide
- (D) Light energy

Q8. BIO

A natural sponge of which approximate size is capable of filtering an entire residential swimming pool in a single day?

- (A) Tennis ball-sized
- (B) Basketball-sized
- (C) Hockey ball-sized
- (D) Teaspoon-sized

Q9. BIO

Infectious, misfolded protein particles that cause fatal neurodegenerative diseases in humans and animals are termed:

- (A) Prions
- (B) Viroids
- (C) Prophages
- (D) Bacteriophages

Q10. BIO

Daniel Koshland proposed the "Induced Fit Model" of enzyme-substrate interaction in which year?

- (A) 1959
- (B) 1952
- (C) 1954
- (D) 1949

Q11. BIO

Ribosomal subunits require which of the following divalent cations to maintain their structural integrity and associate together?

- (A) Ca^{2+}
- (B) Fe^{2+}
- (C) Mg^{2+}
- (D) Zn^{2+}

Q12. BIO

In sickle cell anemia, hemoglobin fails to carry oxygen properly because glutamic acid is replaced by valine at which position of the beta-globin chain?

- (A) 2nd position
- (B) 6th position
- (C) 5th position
- (D) 4th position

Q13. BIO

The accumulation and deposition of hard monosodium urate crystals in synovial joints is diagnosed as:

- (A) Rheumatoid arthritis
- (B) Osteoarthritis
- (C) Gout
- (D) Ankylosing spondylitis

Q14. BIO

Which specialized class of viruses is used in biotechnology to selectively infect, replicate inside, and lyse malignant cancer cells?

- (A) Oncolytic viruses
- (B) Bacteriophages
- (C) Latent proviruses
- (D) Retroviruses

Q15. BIO

The red iron-bearing pigment located within muscle sarcoplasm that functions in binding and storing oxygen is:

- (A) Hemoglobin
- (B) Myoglobin
- (C) Plasmin
- (D) Hemocyanin

Q16. BIO

In Gram-negative bacterial cell walls, the peptidoglycan (murein) layer is characteristically:

- (A) Thick and multi-layered
- (B) Completely absent
- (C) Thin and single-layered
- (D) Located outside the lipopolysaccharide membrane

Q17. BIO

Human metabolic enzymes exhibit their highest catalytic activity and optimum reaction rate at approximately which temperature?

- (A) 15°C
- (B) 25°C
- (C) 37°C
- (D) 55°C

Q18. BIO

Locomotion in segmented worms (phylum Annelida), such as earthworms, is primarily facilitated by circular and longitudinal muscles working in conjunction with:

- (A) Pseudopodia
- (B) Setae (chaetae)
- (C) Flagella
- (D) Ciliated tentacles

Q19. BIO

Carbohydrates composed of short chains of 2 to 10 monosaccharide subunits linked by glycosidic bonds, which are less sweet and less soluble than monosaccharides, are termed:

- (A) Oligosaccharides
- (B) Monosaccharides
- (C) Polysaccharides
- (D) Homopolysaccharides

Q20. BIO

Which quantitative laboratory technique measures the absorbance or transmission of specific light wavelengths to determine bacterial growth, photosynthetic rates, and nucleic acid concentrations?

- (A) Gel electrophoresis
- (B) Paper chromatography
- (C) Micrometry
- (D) Spectrophotometry

Q21. BIO

Which of the following represents a sub-viral infectious agent composed exclusively of a short, circular, single-stranded RNA molecule without a protein capsid that infects plants?

- (A) Prion
- (B) Viroid
- (C) Bacteriophage
- (D) Complex virion

Q22. BIO

During digestion in heterotrophic animals, biological macromolecules are split into their constituent monomer units via the addition of water molecules, catalyzed by:

- (A) Lyases
- (B) Ligases
- (C) Hydrolytic enzymes (hydrolases)
- (D) Isomerases

Q23. BIO

Animals possessing a ladder-type nervous system, characterized by cerebral ganglia linked to two longitudinal nerve cords connected by transverse commissures, belong to the phylum:

- (A) Porifera
- (B) Cnidaria
- (C) Platyhelminthes
- (D) Nematoda

Q24. BIO

The scientific term "enzyme" (meaning "in yeast") was first coined in 1878 by the German physiologist:

- (A) Friedrich Wilhelm Kühne
- (B) Eduard Buchner
- (C) Emil Fischer
- (D) J.B.S. Haldane

Q25. BIO

Which family of ubiquitous, biologically active lipid signaling compounds, derived from arachidonic acid, regulates local inflammatory responses, vasodilation, and pain perception across bodily tissues?

- (A) Prostaglandins
- (B) Mineralocorticoids
- (C) Catecholamines
- (D) Glucagon

Q26. BIO

Under the conditions of genetic equilibrium in a diploid population, the binomial expansion of the Hardy-Weinberg equation is correctly represented as:

- (A) $p^2 + 2pq + q^2 = 1$
- (B) $p^2 + pq + q^2 = 1$
- (C) $2p + 2pq + 2q = 1$
- (D) $p^2 + 2pq + q^2 = 0$

Q27. BIO

In his classic plant tissue culture experiments demonstrating cellular totipotency, F.C. Steward successfully regenerated complete mature plants from cultured phloem cells of which plant?

- (A) Radish
- (B) Carrot (*Daucus carota*)
- (C) Maize
- (D) Pea

Q28. BIO

The core histone octamer proteins responsible for DNA packaging into nucleosomes are characteristically enriched with which type of amino acids?

- (A) Basic amino acids
- (B) Acidic amino acids
- (C) Aromatic amino acids
- (D) Sulfur-containing amino acids

Q29. BIO

In the human male reproductive system, the primary anatomic site where newly formed spermatozoa acquire functional motility, undergo physiological maturation, and are stored is the:

- (A) Seminal vesicles
- (B) Epididymis
- (C) Prostate gland
- (D) Vasa deferentia

Q30. BIO

A clinical condition in human males characterized by the complete and total absence of spermatozoa in the ejaculated seminal fluid is termed:

- (A) Oligospermia
- (B) Azoospermia
- (C) Asthenozoospermia
- (D) Teratozoospermia

Q31. BIO

Which specialized aerobic chemoautotrophic bacterial species is capable of oxidizing toxic carbon monoxide (CO) into carbon dioxide (CO₂) as an energy source?

- (A) *Hydrogenomonas*
- (B) *Bacillus oligocarbophilus* (*Pseudomonas carboxydohydrogena*)
- (C) *Thiobacillus*
- (D) *Azotobacter*

Q32. BIO

The primary constricted chromosomal locus that holds two replicated sister chromatids together and serves as the assembly site for kinetochores is the:

- (A) Centrosome
- (B) Centromere
- (C) Telomere
- (D) Nucleosome

Q33. BIO

The most widely accepted physical theory explaining the continuous upward ascent of sap through the xylem tracheary elements in vascular plants is the:

- (A) Root pressure theory
- (B) Capillarity theory
- (C) Cohesion-tension and transpiration pull theory
- (D) Atmospheric pressure theory

Q34. BIO

Plants that possess extensive aerenchyma tissue containing large interconnected air spaces are most characteristically adapted to which environment?

- (A) Xerophytic environments
- (B) Mesophytic environments
- (C) Hydrophytic (aquatic) environments
- (D) Halophytic environments

Q35. BIO

According to Chargaff's rules of base pairing in double-stranded DNA, if one strand contains an adenine base, the complementary strand will always contain:

- (A) Uracil
- (B) Cytosine
- (C) Guanine
- (D) Thymine

Q36. BIO

Progeny bacteriophages escape from and lyse their bacterial host cell at the conclusion of the lytic cycle primarily through the enzymatic action of:

- (A) Lysozyme (endolysin)
- (B) Protease
- (C) Amylase
- (D) Lipase

Q37. BIO

Which of the following soft-bodied invertebrates is characteristically described as ambisexual (hermaphroditic/monoecious)?

- (A) Tapeworm
- (B) Earthworm
- (C) Snail
- (D) Oyster

Q38. BIO

In human dentition, the total count of deciduous (milk) teeth and permanent teeth is, respectively:

- (A) 18 and 32
- (B) 20 and 32
- (C) 24 and 32
- (D) 20 and 28

Q39. BIO

Which anterior pituitary gonadotropic hormone triggers ovulation and stimulates the conversion of the ruptured Graafian follicle into the corpus luteum?

- (A) Follicle-stimulating hormone
- (B) Adrenocorticotrophic hormone
- (C) Luteinizing hormone
- (D) Thyroid-stimulating hormone

Q40. BIO

When the viral genome of a temperate bacteriophage is integrated stably into the circular bacterial host chromosome, it is known as a:

- (A) Viroid
- (B) Prophage
- (C) Prion
- (D) Capsomere

Q41. BIO

The light-dependent process in which C_3 plants consume oxygen and release carbon dioxide in the presence of sunlight without generating ATP or NADPH is termed:

- (A) Photorespiration
- (B) Oxidative phosphorylation
- (C) Cyclic photophosphorylation
- (D) Lactic acid fermentation

Q42. BIO

A sufficient depolarization of the axolemma (neuronal cell membrane) that reaches the firing threshold results directly in the generation of an:

- (A) Action potential
- (B) Inhibitory postsynaptic potential
- (C) Resting membrane potential
- (D) Electrotonic sub-threshold potential

Q43. BIO

The deliberate cross-breeding of two genetically dissimilar or distinct parent varieties through artificial pollination is termed:

- (A) Acclimatization
- (B) Backcrossing
- (C) Inbreeding
- (D) Hybridization

Q44. BIO

In flowering vascular plants (angiosperms), photosynthetic assimilates are translocated through the phloem sieve tubes primarily in the chemical form of:

- (A) Starch
- (B) Glucose
- (C) Sucrose
- (D) Fructose

Q45. BIO

The linear electron transport pathway of the light-dependent reactions of photosynthesis involving both Photosystem II and Photosystem I is known as the:

- (A) Calvin-Benson cycle
- (B) Z-scheme
- (C) Krebs cycle
- (D) Embden-Meyerhof pathway

Q46. BIO

In gel electrophoresis, negatively charged nucleic acid molecules migrate through the agarose matrix toward the anode under the direct influence of an:

- (A) Agar concentration gradient
- (B) Electric field
- (C) Osmotic pressure gradient
- (D) Active transport pump

Q47. BIO

In simple carbohydrates (hydrates of carbon), hydrogen and oxygen atoms are typically present in which stoichiometric atomic ratio?

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

Q48. BIO

Which group of lipid-soluble accessory photosynthetic pigments is present in both plants and the human body (functioning in the retina and as vitamin A precursors)?

- (A) Chlorophylls
- (B) Phycobilins
- (C) Carotenoids
- (D) Anthocyanins

Q49. BIO

The genetic phenomenon where multiple non-allelic gene pairs at different chromosomal loci influence a single quantitative phenotypic trait in an additive manner is termed:

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

Q50. BIO

The biophysical laboratory method used to isolate and separate individual cellular organelles and components based on their size, shape, and density is termed:

- (A) Chromatography
- (B) Cell fractionation
- (C) Microdissection
- (D) Spectrophotometry

Q51. BIO

The type of cancer common in young men between the ages of 15 and 34 that has a high cure rate with early treatment is:

- (A) Skin cancer
- (B) Lung cancer
- (C) Blood cancer
- (D) Testicular cancer

Q52. BIO

This process inhibits the metabolism and growth of anaerobic microbes used for the treatment of gas gangrene:

- (A) Desiccation
- (B) Radiation
- (C) Hyperbaric oxygen therapy
- (D) Lyophilization

Q53. BIO

The branching network-like arrangement of cardiac muscles is called:

- (A) Epimysium
- (B) Sarcolemma
- (C) Syncytium
- (D) Perimysium

Q54. BIO

Molecules that bind to an enzyme away from the active site and increase the function of that active site are known as:

- (A) Allosteric activators
- (B) Allosteric inhibitors
- (C) Competitive inhibitors
- (D) Coenzymes

Q55. BIO

The maximum number of oxygen molecules that can be transported by one hemoglobin molecule is:

- (A) 1
- (B) 2
- (C) 4
- (D) 6

Q56. BIO

The top milk-producing dairy animal breed is:

- (A) Nili-Ravi
- (B) Bhadawari
- (C) Sahiwal
- (D) Red Sindhi

Q57. BIO

Which of the following is the direct precursor for the biosynthesis of steroid hormones such as testosterone, progesterone, and estrogens?

- (A) Cholesterol
- (B) Choline
- (C) Phosphatidylcholine
- (D) Glycerol

Q58. BIO

A neural cable extending from the brainstem down through the backbone and enclosed within the vertebral column is called the:

- (A) Meninges
- (B) Spinal cord
- (C) Axon
- (D) Cauda equina

Q59. BIO

Which of the following accurately describes the morphology and motility of *Helicobacter pylori*?

- Ⓐ Non-flagellated rod-shaped bacterium
- Ⓑ Flagellated chain bacterium
- Ⓒ Flagellated spiral-shaped bacterium
- Ⓓ Non-flagellated coccus

Q60. BIO

Water has a very high specific heat of vaporization of approximately:

- Ⓐ 274 kcal/kg
- Ⓑ 374 kcal/kg
- Ⓒ 474 kcal/kg
- Ⓓ 574 kcal/kg

Q61. BIO

Which specialized mature cells are embedded within lacunae and are responsible for maintaining the extracellular matrix of cartilage?

- Ⓐ Osteocytes
- Ⓑ Chondrocytes
- Ⓒ Fibroblasts
- Ⓓ Osteoblasts

Q62. BIO

Emotional behavioral responses, particularly fear, rage, and defensive behavior, are primarily integrated and controlled by the:

- Ⓐ Pituitary gland
- Ⓑ Cerebellum
- Ⓒ Amygdala
- Ⓓ Hippocampus

Q63. BIO

In skeletal muscle fibers, which transverse tubular system runs perpendicularly from the sarcolemma and associates closely with the sarcoplasmic reticulum?

- Ⓐ Troponin tubules
- Ⓑ T-tubules
- Ⓒ Myofibrils
- Ⓓ Sarcoplasmic tubules

Q64. BIO

The active site of an enzyme is defined as the specific catalytic region that:

- Ⓐ Binds with the end products of the reaction
- Ⓑ Directly binds substrate molecules and carries out the catalytic reaction
- Ⓒ Binds allosteric regulators of the enzyme
- Ⓓ Permanently denatures upon heating

Q65. BIO

Frostbite injuries resulting from extreme cold exposure are primarily caused by severe, prolonged:

- Ⓐ Fluid retention
- Ⓑ Cutaneous vasodilation
- Ⓒ Peripheral vasoconstriction
- Ⓓ Muscular hypertrophy

Q66. BIO

In which region of the brain are neurosecretory cells located that regulate the secretions of the anterior pituitary gland by releasing hypophysiotropic hormones?

- Ⓐ Pons
- Ⓑ Hypothalamus
- Ⓒ Hippocampus
- Ⓓ Amygdala

Q67. BIO

Which quaternary globular iron-containing protein transports oxygen from the respiratory surfaces of the lungs to tissues throughout the human body?

- Ⓐ Hemoglobin
- Ⓑ Myoglobin
- Ⓒ Albumin
- Ⓓ Transferrin

Q68. BIO

A rare condition of color blindness where an individual lacks functional blue cone photoreceptors and cannot perceive blue color is termed:

- Ⓐ Protanopia
- Ⓑ Deutanopia
- Ⓒ Tritanopia
- Ⓓ Monochromacy

CHEM SECTION: CHEMISTRY

Questions 69 to 122 (54 MCQs)

Q69. CHEM

The term "chelate" is derived from a Greek word meaning:

- (A) Bidentate
- (B) Ring
- (C) Crab claws
- (D) Complex

Q70. CHEM

According to VSEPR theory, the molecular geometry of an ammonia (NH_3) molecule is:

- (A) Tetrahedral
- (B) Trigonal planar
- (C) Trigonal pyramidal
- (D) Bent

Q71. CHEM

Which carboxylic acid is used as a preservative and antibacterial agent in livestock feed and grain storage?

- (A) Butyric acid
- (B) Formic acid
- (C) Propionic acid
- (D) Valeric acid

Q72. CHEM

The magnitude of the elementary charge of an electron is:

- (A) $1.602 \times 10^{-19} \text{ C}$
- (B) $1.602 \times 10^{-16} \text{ C}$
- (C) $1.602 \times 10^{-18} \text{ C}$
- (D) $1.602 \times 10^{-21} \text{ C}$

Q73. CHEM

The position of chemical equilibrium in which of the following gaseous reactions will not be affected by an increase in total external pressure?

- (A) $2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g)$
- (B) $\text{N}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{NO}(g)$
- (C) $2\text{NO}(g) + \text{Cl}_2(g) \rightleftharpoons 2\text{NOCl}(g)$
- (D) $\text{PCl}_5(g) \rightleftharpoons \text{PCl}_3(g) + \text{Cl}_2(g)$

Q74. CHEM

The density of liquid benzene (C_6H_6) at room temperature is approximately:

- (A) 0.80 g/cm^3
- (B) 0.88 g/cm^3
- (C) 0.95 g/cm^3
- (D) 1.00 g/cm^3

Q75. CHEM

According to Raoult's law for non-volatile, non-electrolyte solutes, the relative lowering of vapor pressure is equal to the:

- (A) Mole fraction of the solute
- (B) Mole fraction of the solvent
- (C) Molarity of the solution
- (D) Molality of the solution

Q76. CHEM

According to Markovnikov's rule, when an unsymmetrical reagent adds to an unsymmetrical alkene, the negative part of the reagent attaches to the double-bonded carbon that has the:

- (A) Greater number of hydrogen atoms
- (B) Lesser number of hydrogen atoms
- (C) Greater number of halogen atoms
- (D) Equal number of hydrogen atoms

Q77. CHEM

According to Charles's law, at absolute zero (0 K or -273.15°C), the volume of an ideal gas theoretically becomes:

- (A) Infinite
- (B) Zero
- (C) 22.4 dm^3
- (D) Negative

Q78. CHEM

The paramagnetic behavior of diatomic oxygen (O_2) molecules cannot be explained by:

- (A) Molecular Orbital Theory
- (B) Valence Bond Theory
- (C) Band Theory
- (D) Crystal Field Theory

Q79. CHEM

The spontaneous decomposition of aqueous hydrogen peroxide (H_2O_2) is inhibited by the addition of small amounts of:

- (A) MnO_2
- (B) Glycerin (glycerol)
- (C) Platinum powder
- (D) V_2O_5

Q80. CHEM

The carbon-carbon (C – C) bond length in a benzene ring is intermediate between single and double bonds, measuring:

- (A) 1.20 Å
- (B) 1.34 Å
- (C) 1.39 Å
- (D) 1.54 Å

Q81. CHEM

"No two electrons in the same atom can have an identical set of all four quantum numbers." This fundamental statement is known as:

- (A) Hund's rule of maximum multiplicity
- (B) Aufbau principle
- (C) Pauli's exclusion principle
- (D) Heisenberg's uncertainty principle

Q82. CHEM

The systematic IUPAC name of isopropyl alcohol is:

- (A) 1-Propanol
- (B) 2-Propanol
- (C) 2-Butanol
- (D) 2-Methyl-2-propanol

Q83. CHEM

The SI unit of the specific rate constant (k) for a first-order chemical reaction is:

- (A) $\text{mol} \cdot \text{dm}^{-3} \cdot \text{s}^{-1}$
- (B) $\text{dm}^3 \cdot \text{mol}^{-1} \cdot \text{s}^{-1}$
- (C) s^{-1}
- (D) $\text{dm}^6 \cdot \text{mol}^{-2} \cdot \text{s}^{-1}$

Q84. CHEM

In thermodynamics, volume (V) is classified as an extensive property and a:

- (A) Path function
- (B) State function
- (C) Work function
- (D) Non-equilibrium function

Q85. CHEM

The calculation of the partial pressure of a dry gas collected over water by subtracting the aqueous tension illustrates:

- (A) Boyle's law
- (B) Graham's law
- (C) Dalton's law of partial pressures
- (D) Avogadro's law

Q86. CHEM

Dry ice (solid carbon dioxide, CO_2) is a classic example of a:

- (A) Ionic solid
- (B) Covalent network solid
- (C) Molecular solid
- (D) Metallic solid

Q87. CHEM

In meteorological and atmospheric science, a regional low-pressure system is referred to as a:

- (A) Depression
- (B) Anticyclone
- (C) Diffusion system
- (D) Compression zone

Q88. CHEM

The normal physiological pH range of healthy human arterial blood is tightly regulated at approximately:

- (A) 6.80 to 7.00
- (B) 7.35 to 7.45
- (C) 7.80 to 8.00
- (D) 7.05 to 7.15

Q89. CHEM

Which diagnostic chemical reagent, consisting of anhydrous zinc chloride in concentrated hydrochloric acid, is used to distinguish between primary, secondary, and tertiary alcohols?

- (A) Tollens' reagent
- (B) Lucas reagent
- (C) Benedict's reagent
- (D) Fehling's solution

Q90. CHEM

Which of the following biochemical processes is an endothermic reaction?

- (A) Photosynthesis
- (B) Cellular respiration
- (C) Combustion of glucose
- (D) Neutralization of an acid by a base

Q91. CHEM

Stoichiometry is defined as the branch of chemistry that studies the ___ relationships between reactants and products based on a balanced chemical equation:

- (A) Qualitative
- (B) Quantitative
- (C) Empirical
- (D) Kinetic

Q92. CHEM

When aliphatic ketones are reduced using lithium aluminum hydride (LiAlH_4), they yield:

- (A) Primary alcohols
- (B) Secondary alcohols
- (C) Tertiary alcohols
- (D) Carboxylic acids

Q93. CHEM

In the Law of Mass Action, the term "active mass" is mathematically defined as the molar concentration expressed in:

- (A) Grams per decimeter cubed
- (B) Moles per decimeter cubed ($\text{mol} \cdot \text{dm}^{-3}$)
- (C) Moles per square decimeter
- (D) Grams per mole

Q94. CHEM

The subatomic neutral particle, the neutron, was discovered in 1932 by:

- (A) J.J. Thomson
- (B) Ernest Rutherford
- (C) James Chadwick
- (D) Niels Bohr

Q95. CHEM

In the industrial Dow process, when chlorobenzene reacts with aqueous sodium hydroxide at 350°C and 150 atm pressure, the immediate intermediate product formed prior to acidification is:

- (A) Phenol
- (B) Sodium phenoxide
- (C) Benzene
- (D) Benzoic acid

Q96. CHEM

Aliphatic carboxylic acids are stronger Bronsted-Lowry acids than which of the following compounds?

- (A) Hydrochloric acid (HCl)
- (B) Sulfuric acid (H_2SO_4)
- (C) Nitric acid (HNO_3)
- (D) Methanol (CH_3OH)

Q97. CHEM

The major natural gas field in Pakistan was first discovered in the Sui area of Balochistan in the year:

- (A) 1947
- (B) 1952
- (C) 1956
- (D) 1965

Q98. CHEM

The direct reduction of carbonyl groups in aldehydes and ketones to methylene ($-\text{CH}_2-$) groups of alkanes using zinc amalgam ($\text{Zn} - \text{Hg}$) and concentrated hydrochloric acid is known as:

- (A) Wolff-Kishner reduction
- (B) Clemmensen reduction
- (C) Rosenmund reduction
- (D) Sabatier-Senderens reaction

Q99. CHEM

Dietary deficiency of which trace mineral element causes loss of appetite (anorexia), impaired sense of taste (hypogeusia), and delayed wound healing?

- (A) Iron (Fe)
- (B) Zinc (Zn)
- (C) Potassium (K)
- (D) Phosphorus (P)

Q100. CHEM

The reaction rate of a unimolecular nucleophilic substitution ($\text{S}_\text{N}1$) mechanism depends directly on the concentration of the:

- (A) Nucleophile only
- (B) Substrate only
- (C) Both substrate and nucleophile
- (D) Catalyst only

Q101. CHEM

The total number of alpha amino acids that participate in protein synthesis in biological systems is:

- (A) 19
- (B) 20
- (C) 22
- (D) 25

Q102. CHEM

Which statement about tautomerism is correct?

- (A) Only occurs in inorganic compounds
- (B) Is not influenced by temperature
- (C) Tautomers possess the same molecular formula
- (D) Tautomers have identical physical and chemical properties

Q103. CHEM

Aldehydes and ketones can be reduced directly into alkanes using hydrazine in the presence of strong base. This reaction is called the:

- (A) Lucas test
- (B) Wolff-Kishner reaction
- (C) Grignard reaction
- (D) Friedel-Crafts reaction

Q104. CHEM

An example of a bidentate ligand among the following is:

- (A) Br^-
- (B) CN^-
- (C) $\text{C}_2\text{O}_4^{2-}$ (oxalate ion)
- (D) OH^-

Q105. CHEM

A hydrogen fuel cell is an electrochemical galvanic cell that continuously converts chemical energy into electricity via the reaction between:

- (A) Hydrogen and copper
- (B) Methane and oxygen
- (C) Hydrogen and oxygen
- (D) Nitrogen and oxygen

Q106. CHEM

Which alkali metal produces a characteristic persistent golden-yellow coloration in a flame test?

- (A) Barium (Ba)
- (B) Sodium (Na)
- (C) Potassium (K)
- (D) Cesium (Cs)

Q107. CHEM

Which of the following monoatomic or diatomic species possesses the weakest London dispersion forces?

- (A) F_2
- (B) Cl_2
- (C) Br_2
- (D) He

Q108. CHEM

Among the following pure liquids, which exhibits the highest surface tension at room temperature?

- (A) Water
- (B) Mercury
- (C) Ethyl alcohol
- (D) Benzene

Q109. CHEM

Hydroquinone (quinol) is a dihydroxybenzene derivative containing two hydroxyl ($-\text{OH}$) groups attached at positions:

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

Q110. CHEM

In practical chemical synthesis, the actual yield obtained experimentally is generally:

- (A) Less than theoretical yield
- (B) Equal to theoretical yield
- (C) Greater than theoretical yield
- (D) Unrelated to theoretical yield

Q111. CHEM

Formic acid (methanoic acid, HCOOH) is naturally produced in the venom and defensive stings of:

- (A) Honeybees
- (B) Ants
- (C) Wasps
- (D) Scorpions

Q112. CHEM

Friedrich Wohler synthesized urea in 1828 by heating which inorganic precursor compound, thereby disproving the vital force theory?

- (A) Ammonium nitrate
- (B) Ammonium cyanate
- (C) Ammonium chloride
- (D) Ammonium carbonate

Q113. CHEM

Historically, concentrated sulfuric acid (H_2SO_4) was referred to by alchemists and early chemists as:

- (A) Caustic soda
- (B) Aqua regia
- (C) Oil of vitriol
- (D) Muriatic acid

Q114. CHEM

A molecule of Buckminsterfullerene (C_{60} , Buckyball) is constructed from how many five-membered (pentagonal) and six-membered (hexagonal) carbon rings, respectively?

- (A) 20 and 12
- (B) 12 and 20
- (C) 14 and 14
- (D) 12 and 12

Q115. CHEM

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

- (A) Glass
- (B) Rubber
- (C) Plastics
- (D) Potash alum

Q116. CHEM

According to VSEPR theory, the molecular geometry around the nitrogen atom in primary aliphatic amines ($R-NH_2$) is:

- (A) Trigonal planar
- (B) Trigonal pyramidal
- (C) Regular tetrahedral
- (D) Linear

Q117. CHEM

Most non-metallic p-block elements readily react directly with ___ to form binary covalent compounds:

- (A) Halogens
- (B) Noble gases
- (C) Alkali metals only
- (D) Transition metals only

Q118. CHEM

The maximum number of electrons that can be accommodated in a given atomic subshell defined by azimuthal quantum number l is calculated using the formula:

- (A) $2l + 1$
- (B) $2(2l + 1)$
- (C) $2n^2$
- (D) n^2

Q119. CHEM

In VSEPR classification, a molecule designated as AX_2 with zero lone pairs on the central atom possesses a bond angle of 180° and a geometry that is:

- (A) Bent
- (B) Trigonal planar
- (C) Linear
- (D) Tetrahedral

Q120. CHEM

A colloidal dispersion consisting of microscopic droplets of one liquid dispersed uniformly throughout another immiscible liquid is known as an:

- (A) Aerosol
- (B) Sol
- (C) Emulsion
- (D) Gel

Q121. CHEM

Hydrocarbons containing one or more carbon-carbon double bonds or triple bonds in their chemical structure are:

- (A) Alkanes and cycloalkanes
- (B) Alkenes and alkynes
- (C) Alkanes and alkyl halides
- (D) Alcohols and ethers

Q122. CHEM

According to the Bronsted-Lowry acid-base theory, the conjugate acid of ammonia (NH_3) is:

- (A) NH_2^-
- (B) NH_4^+
- (C) NH_2^{2-}
- (D) N^{3-}

PHY SECTION: PHYSICS

Questions 123 to 176 (54 MCQs)

Q123. PHY

The linear momentum (p) of a photon of frequency ν traveling at the speed of light c is expressed as:

- (A) $h\nu c$
- (B) $\frac{h\nu}{c}$
- (C) $\frac{c}{h\nu}$
- (D) mc^2

Q124. PHY

The SI derived unit of electrical resistance is the:

- (A) Volt
- (B) Ohm
- (C) Siemens
- (D) Ampere

Q125. PHY

Which of the following wave phenomena is exhibited exclusively by transverse waves and cannot be exhibited by longitudinal sound waves?

- (A) Reflection
- (B) Refraction
- (C) Polarization
- (D) Interference

Q126. PHY

If a mass of 1 kg is completely converted into energy, the total amount of energy released according to mass-energy equivalence is:

- (A) 9×10^{16} J
- (B) 3×10^8 J
- (C) 9×10^{10} J
- (D) 3×10^{16} J

Q127. PHY

The SI unit of electrical resistivity (ρ) of a conducting material is:

- (A) $\Omega \cdot \text{m}$
- (B) Ω/m
- (C) $\Omega^{-1} \cdot \text{m}^{-1}$
- (D) $\text{V} \cdot \text{m}$

Q128. PHY

The SI derived unit of power, defined as one joule of energy transferred per second, is the:

- (A) Joule
- (B) Watt
- (C) Newton
- (D) Pascal

Q129. PHY

The total potential difference across a combination of three identical electric cells becomes maximum when:

- (A) All three cells are connected in parallel
- (B) Two cells are in parallel and the third is in series
- (C) All three cells are connected in series
- (D) Two cells are in series and the third is in parallel

Q130. PHY

Which of the following statements is scientifically correct regarding an electrical transformer?

- (A) A transformer converts direct current (DC) into alternating current (AC)
- (B) A transformer operates on the principle of mutual electromagnetic induction
- (C) A transformer converts mechanical energy into electrical energy
- (D) A transformer operates using steady, non-fluctuating DC voltages

Q131. PHY

According to Newton's second law of motion, the time rate of change of linear momentum of a body is equal to the:

- (A) Applied net force
- (B) Kinetic energy
- (C) Applied torque
- (D) Impulse

Q132. PHY

In ideal projectile motion (ignoring air resistance), the horizontal component of acceleration is:

- (A) 9.8 m/s^2
- (B) Zero
- (C) Dependent on the launch angle
- (D) Equal to the vertical acceleration

Q133. PHY

Which of the following thermodynamic statements is correct?

- (A) Mechanical work can be converted completely and continuously into heat
- (B) Heat can be converted completely and continuously into mechanical work in a cyclic process without any loss
- (C) Work can never be converted into heat
- (D) Heat and work are not interconvertible forms of energy

Q134. PHY

The restoring force responsible for producing simple harmonic motion in a simple pendulum of mass m displaced by an angle θ is given by:

- (A) $mg \cos \theta$
- (B) $mg \tan \theta$
- (C) $mg \sin \theta$
- (D) $mg \sin^2 \theta$

Q135. PHY

"The electric current flowing through a metallic conductor is directly proportional to the potential difference applied across its ends, provided temperature and other physical conditions remain constant." This is the statement of:

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

Q136. PHY

The electrical energy transferred or work done per unit electric charge moved between two points in an electrical circuit is defined as:

- (A) Electric resistance
- (B) Electric capacitance
- (C) Potential difference
- (D) Electric power

Q137. PHY

In the atomic emission spectrum of hydrogen, electronic transitions terminating at the second principal energy level ($n = 2$) produce the spectral lines of the:

- (A) Lyman series
- (B) Balmer series
- (C) Paschen series
- (D) Brackett series

Q138. PHY

The magnitude of the magnetic force (F) experienced by a straight conductor of length L carrying current I placed in a uniform magnetic field B at an angle θ is given by:

- (A) $F = qvB \sin \theta$
- (B) $F = BIL \cos \theta$
- (C) $F = BIL \sin \theta$
- (D) $F = \frac{BIL}{\sin \theta}$

Q139. PHY

The ratio of the universal molar gas constant (R) to Avogadro's number (N_A) defines:

- (A) Planck's constant
- (B) Boltzmann constant
- (C) Rydberg constant
- (D) Stefan-Boltzmann constant

Q140. PHY

"The electrostatic force of attraction or repulsion between two stationary point charges is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them." This law is known as:

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

Q141. PHY

In nuclear physics, the product of the half-life ($T_{1/2}$) of a radioisotope and its decay constant (λ) is equal to:

- (A) 0.693
- (B) 0.369
- (C) 1.440
- (D) 0.500

Q142. PHY

The work done in moving a unit positive test charge from one point to another against an electrostatic field, or the change in electrostatic potential energy per unit charge, is:

- (A) Electric field intensity
- (B) Electric potential difference
- (C) Electric permittivity
- (D) Capacitance

Q143. PHY

Which of the following statements is correct regarding the magnetic force exerted on a charged particle moving through a magnetic field?

- (A) The magnetic field exerts maximum force when the particle moves parallel to the field lines
- (B) The magnetic field exerts zero force when the particle moves perpendicular to the field lines
- (C) The magnetic field exerts maximum force when the particle moves perpendicular to the field lines
- (D) The magnetic field always exerts a force regardless of particle velocity or direction

Q144. PHY

The electrical resistivity (ρ) of a metallic conductor depends intrinsically on the:

- (A) Length of the conductor
- (B) Cross-sectional area of the conductor
- (C) Nature of the material and temperature
- (D) Shape and volume of the conductor

Q145. PHY

The speed of propagation of electromagnetic waves (c) in free space (vacuum) is approximately:

- (A) 3×10^8 m/s
- (B) 3×10^6 m/s
- (C) 3×10^{10} m/s
- (D) 3×10^5 m/s

Q146. PHY

A machine operating at a constant power output of 6 W delivers how much total energy in 2 minutes?

- (A) 12 J
- (B) 120 J
- (C) 720 J
- (D) 360 J

Q147. PHY

A thermodynamic process occurring at constant temperature during which all heat supplied to an ideal gas is converted entirely into work is an:

- (A) Isochoric process
- (B) Isobaric process
- (C) Adiabatic process
- (D) Isothermal process

Q148. PHY

The charge-to-mass ratio (e/m) of an electron is approximately:

- (A) 1.76×10^{11} C/kg
- (B) 1.602×10^{-19} C/kg
- (C) 9.11×10^{-31} C/kg
- (D) 1.76×10^8 C/kg

Q149. PHY

When the instantaneous velocity of a moving body is equal to its average velocity over any given time interval, the body is moving with:

- (A) Uniform acceleration
- (B) Uniform velocity
- (C) Variable acceleration
- (D) Constant non-zero jerk

Q150. PHY

Waves that strictly require a material medium (solid, liquid, or gas) for their transmission and cannot propagate through a vacuum are called:

- (A) Electromagnetic waves
- (B) Mechanical waves
- (C) Matter waves
- (D) Photonic waves

Q151. PHY

The SI unit of electric field intensity is:

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

Q152. PHY

An electron and a proton enter a uniform magnetic field perpendicularly with the same linear momentum. Which of the following statements is correct regarding their paths?

- (A) They will move undeflected in opposite directions
- (B) The electron deflects more than the proton
- (C) They will deflect equally with circular paths of the same radius
- (D) The proton deflects more than the electron

Q153. PHY

A body starts from rest and falls freely under gravity. The distance covered by it in t seconds is given by:

- (A) $0.5gt^2$
- (B) gt
- (C) $0.5gt$
- (D) g^2t^2

Q154. PHY

The total mechanical energy E of a mass-spring system executing simple harmonic motion at any displacement x is:

- (A) $-2kx^2$
- (B) $0.5kx_0^2$
- (C) $-kx^2$
- (D) kx

Q155. PHY

A reverse-biased p-n junction semiconductor diode behaves essentially as an:

- (A) On switch (closed switch)
- (B) Inverter
- (C) Off switch (open switch)
- (D) Amplifier

Q156. PHY

For maximum work done by a constant force, the angle between the force vector and displacement vector must be:

- (A) 45°
- (B) 90°
- (C) 65°
- (D) 0°

Q157. PHY

A body moves along a circular path with constant speed. Which of the following statements is true?

- (A) There is a force acting on the body tangent to the circle
- (B) There is a net force acting on the body directed toward the center of the circle
- (C) There is zero acceleration in the body
- (D) The net force acting on the body is zero

Q158. PHY

The SI unit of electric potential difference is the:

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

Q159. PHY

In the SI system of units, specific heat capacity (c) is measured in:

- (A) $\text{J} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$
- (B) $\text{J} \cdot \text{kg}$
- (C) $\text{J} \cdot \text{kg}^{-1} \cdot ^\circ\text{C}$
- (D) $\text{J} \cdot \text{g}^{-1} \cdot ^\circ\text{C}^{-1}$

Q160. PHY

The time period (T) of uniform circular motion is related to angular frequency (ω) by the formula:

- (A) $T = \frac{\omega}{2\pi}$
- (B) $T = \frac{2\pi}{\omega}$
- (C) $T = 2\pi\omega$
- (D) $T = 2\pi\omega^2$

Q161. PHY

In the photoelectric threshold relationship $\Phi = h\nu_0$, the physical symbol Φ represents the:

- (A) Magnetic flux
- (B) Threshold frequency
- (C) Work function of the metal
- (D) Electric flux

Q162. PHY

The base physical definition of electric current gives its unit as amperes, which is equivalent to:

- (A) Volts per second
- (B) Ohms per second
- (C) Joules per second
- (D) Coulombs per second

Q163. PHY

Fast-moving electrons abruptly decelerated upon striking a heavy metallic target in an evacuated tube produce:

- (A) Beta rays
- (B) Gamma rays
- (C) X-rays
- (D) Alpha rays

Q164. PHY

The instantaneous alternating electromotive force ($\mathcal{E}$) generated by an AC generator of N turns and coil area A rotating with angular velocity ω in magnetic field B is given by:

- (A) $\mathcal{E} = BvL \sin \theta$
- (B) $\mathcal{E} = NBL \sin \theta$
- (C) $\mathcal{E} = NBL \cos \theta$
- (D) $\mathcal{E} = NAB\omega \sin(\omega t)$

Q165. PHY

In an n-type semiconductor material, the minority charge carriers are:

- (A) Photons
- (B) Free electrons
- (C) Holes
- (D) Protons

Q166. PHY

If the total binding energy of a deuteron (${}^2_1\text{H}$) nucleus is 2.3 MeV, its binding energy per nucleon is:

- (A) 0.51 MeV
- (B) 2.30 MeV
- (C) 1.02 MeV
- (D) 1.15 MeV

Q167. PHY

The mathematical relationship between magnetic flux (Φ) and magnetic flux density (B) across a surface area A is:

- (A) $\Phi = BA \cos \theta$
- (B) $\Phi = B\Delta t \cos \theta$
- (C) $B = \Phi \Delta t \cos \theta$
- (D) $\Phi = BA \sin \theta$

Q168. PHY

If the length of a simple pendulum is increased by four times, its frequency of oscillation will:

- (A) Increase by 2 times
- (B) Decrease by 4 times
- (C) Remain the same
- (D) Decrease by 2 times

Q169. PHY

In the beta-plus nuclear decay equation ${}_1^1p \rightarrow {}_0^1n + X + \nu_e$, the emitted particle X is a:

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

Q170. PHY

A force of magnitude 10 N acts entirely along the positive x-axis. Its rectangular component along the y-axis is:

- (A) Zero
- (B) 5 N
- (C) 10 N
- (D) 20 N

Q171. PHY

The atomic number (proton number) of a radioactive nucleus increases by one after the emission of a:

- (A) Negative beta particle (β^-)
- (B) Positive beta particle (β^+)
- (C) Alpha particle (α)
- (D) Neutron

Q172. PHY

In Coulomb's law $F = k \frac{q_1 q_2}{r^2}$, the factor k is the:

- (A) Permittivity of free space
- (B) Electrostatic constant of proportionality
- (C) Relative permittivity of the medium
- (D) Dielectric constant

Q173. PHY

Newton (N) is not the SI unit of which of the following physical quantities?

- (A) Centripetal force
- (B) Tension
- (C) Friction
- (D) Linear momentum

Q174. PHY

In the radioactive decay law $N(t) = N_0 e^{-\lambda t}$, the ratio $\frac{N(t)}{N_0}$ represents the:

- (A) Disintegration rate
- (B) Relative activity (surviving fraction)
- (C) Half-life
- (D) Decay constant

Q175. PHY

In Einstein's photoelectric equation $h\nu = \Phi + K_{\max}$, the maximum kinetic energy of emitted photoelectrons is given by:

- (A) $K_{\max} = \Phi + h\nu$
- (B) $K_{\max} = h\nu - \Phi$
- (C) $K_{\max} = \Phi - h\nu$
- (D) $K_{\max} = \frac{h\nu}{\Phi}$

Q176. PHY

Faraday's law of electromagnetic induction for a coil of N turns is mathematically represented as:

- (A) $E = -N \frac{\Delta B}{\Delta t}$
- (B) $E = -N \frac{\Delta I}{\Delta t}$
- (C) $E = -N \frac{\Delta \Phi}{\Delta t}$
- (D) $E = -\frac{1}{N} \frac{\Delta \Phi}{\Delta t}$

ENG SECTION: ENGLISH

Questions 177 to 194 (18 MCQs)

Q177. ENG

Spot the error in the given sentence:

The stories that she makes up for (A) the children ought (C) to be written down (B) and published. (D) No error

- (A) For
- (B) Down
- (C) Ought
- (D) No error

Q178. ENG

Read the passage and choose the correct answer:

"As the big door swung behind me, I heard the sound of a roar of laughter that went up to the roof of the bank. Since then I use a bank no more. I keep my money in my pocket and my savings in silver dollars in a sock."

Where did the narrator keep his savings?

- (A) In a pocket
- (B) In a silver box
- (C) In a bank
- (D) In a sock

Q179. ENG

Choose the grammatically correct sentence:

- (A) Although he very ill, he managed to write a letter to his son.
- (B) He was very ill, he managed to write a letter to his son.
- (C) He managed to write a letter to his son although he was very ill.
- (D) Although he was very ill, he managed to write a letter to his son.

Q180. ENG

Read the passage and answer the question:

John Keats (1795–1821) was born in London. In 1818, his brother Tom died of tuberculosis. Soon after, Keats himself developed symptoms of the same disease and died in Rome in 1821.

John Keats and his brother Tom died of which disease?

- (A) Pneumonia
- (B) Tuberculosis
- (C) Typhoid
- (D) Cholera

Q181. ENG

Choose the correct phrasal verb to complete the sentence:

The airplane traveled 5,000 meters before it _____.

- (A) Took into
- (B) Took off
- (C) Took over
- (D) Took away

Q182. ENG

Choose the correct homophone to complete the sentence:

How will they get across the river if the _____ is not running?

- (A) Furry
- (B) Fairy
- (C) Ferry
- (D) Fury

Q183. ENG

Choose the most appropriate antonym for the underlined word:

The general's problem was to get 20,000 troops swiftly across this river.

- (A) Slowly
- (B) Thoroughly
- (C) Anxiously
- (D) Strongly

Q184. ENG

Choose the correctly sequenced set of words to complete the passage:

"_____ the invention of the personal computer, everyday tasks changed dramatically. Jobs could now be completed much _____ than before. _____ and _____ text was also simplified. As a result, reports became _____ and more detailed. A _____ processor program allowed users to format writing with ease. _____, computers are indispensable tools."

- (A) With - Faster - Writing - Editing - Longer - Word - Now
- (B) Longer - With - Faster - Writing - Editing - Word - Now
- (C) With - Now - Faster - Writing - Editing - Longer - Word
- (D) Now - With - Faster - Writing - Editing - Longer - Word

Q185. ENG

Choose the word closest in meaning (synonym) to the word "Oblivion":

- (A) Forgetfulness
- (B) Observance
- (C) Diligence
- (D) Alertness

Q186. ENG

Choose the correct possessive pronoun to complete the sentence:

Some of the race teams were still looking for _____ equipment.

- (A) Its
- (B) It's
- (C) There
- (D) Their

Q187. ENG

Read the passage and answer the question:

"Nobody has ever been able to compute with any exactness how many people took part in the great rout of 1913... Few people got as far east as Reynoldsburg; fifty or more reached the Country Club; most of the others gave up, exhausted, or climbed trees in Franklin Park, four miles out."

According to the passage, where did most of the exhausted people give up and climb trees?

- (A) Winslow Bottling Works
- (B) Clintonville
- (C) Country Club
- (D) Franklin Park

Q188. ENG

Choose the correct prepositional phrase to complete the sentence:

In today's session, the analyst will _____ the economic situation of Pakistan.

- (A) Suffer from
- (B) Compare with
- (C) Comment on
- (D) Beg for

Q189. ENG

Spot the error in the given sentence:

The bushes on the corner make (C) it difficult for (B) the driver to see the traffic approaching (D) from the write (A).

- (A) Write
- (B) For
- (C) Make
- (D) Approaching

Q190. ENG

Choose the sentence punctuated correctly for direct speech:

- (A) He said, "Will you have time to play regularly?"
- (B) He said, Will you have time to play regularly?
- (C) He said "Will you have time to play regularly."
- (D) He said, 'Will you have time to play regularly.'

Q191. ENG

Complete the second conditional sentence appropriately:

If I went to Paris, I _____ the Eiffel Tower.

- (A) Can see
- (B) Must see
- (C) Will see
- (D) Would see

Q192. ENG

Correct the spelling and capitalization errors in the following passage:

"It was in korea, june 1953. I had been wounded, and they had strapt me on a stretcher... when I came to, there was a korean girl sitting beside me with friendly blue eyes and long plates hanging in front of her shoulders."

- (A) Korea - June - Strapped - Korean - Plaits
- (B) Korea - June - Strapt - Korean - Plates
- (C) korea - june - Strapped - Korean - Plaits
- (D) Korea - June - Strapped - korean - Plates

Q193. ENG

Choose the correct verb tense form to complete the third conditional sentence:

I would gladly have helped him if he _____ me into confidence.

- (A) Took
- (B) Has taken
- (C) Had taken
- (D) Would take

Q194. ENG

Choose the correct preposition to complete the sentence:

The prisoner made an escape by climbing _____ the wall.

- (A) Up
- (B) Over
- (C) Into
- (D) At

LOGIC SECTION: LOGICAL REASONING

Questions 195 to 200 (6 MCQs)

Q195. LOGIC

Read the statement and evaluate the suggested courses of action:

Statement: A public sector television channel is concerned about the quality of its programs and, considering competition from private channels, has decided to provide incentives to attract creative talent.

Courses of action:

- I. The public sector channel should revise its fee structure for performing artists.
II. The channel should not revise its fee structure until private channels do so.

- (A) Only I follows
(B) Only II follows
(C) Either I or II follows
(D) Neither I nor II follows

Q196. LOGIC

Parveen, Qadir, Rehan, Salim, and Tehmina are members of a family. Parveen is the daughter of Qadir. Qadir is the son of Rehan. Rehan is the father of Salim. Tehmina is the daughter of Parveen. Which of the following statements is logically true?

- (A) Rehan is the uncle of Parveen
(B) Qadir is the grandfather of Tehmina
(C) Salim is the daughter of Qadir
(D) Parveen is the sister of Tehmina

Q197. LOGIC

Identify the underlying mathematical pattern and deduce the next number in the series:

1, 4, 9, 16, ___

- (A) 20
(B) 24
(C) 25
(D) 36

Q198. LOGIC

Read the two statements and determine the correct cause-and-effect relationship:

Statement A: Advances in cancer chemotherapy have made more targeted drugs available today.

Statement B: A large number of cancer patients now have improved clinical outcomes.

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

Q199. LOGIC

Which of the following two-digit numbers is divisible by the product of its digits?

- (A) 21
(B) 47
(C) 52
(D) 24

Q200. LOGIC

Examine the pattern in the letter sequences and select the option that follows logically:

VSA, WRD, XQG, YPJ, ___

- (A) ZOM
(B) ZNE
(C) TLK
(D) VTC

OFFICIAL VERIFIED ANSWER KEY

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Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB
1	B	BIO	41	A	BIO	81	C	CHEM	121	B	CHEM	161	C	PHY
2	A	BIO	42	A	BIO	82	B	CHEM	122	B	CHEM	162	D	PHY
3	A	BIO	43	D	BIO	83	C	CHEM	123	B	PHY	163	C	PHY
4	C	BIO	44	C	BIO	84	B	CHEM	124	B	PHY	164	D	PHY
5	D	BIO	45	B	BIO	85	C	CHEM	125	C	PHY	165	C	PHY
6	B	BIO	46	B	BIO	86	C	CHEM	126	A	PHY	166	D	PHY
7	A	BIO	47	A	BIO	87	A	CHEM	127	A	PHY	167	A	PHY
8	B	BIO	48	C	BIO	88	B	CHEM	128	B	PHY	168	D	PHY
9	A	BIO	49	B	BIO	89	B	CHEM	129	C	PHY	169	B	PHY
10	A	BIO	50	B	BIO	90	A	CHEM	130	B	PHY	170	A	PHY
11	C	BIO	51	D	BIO	91	B	CHEM	131	A	PHY	171	A	PHY
12	B	BIO	52	C	BIO	92	B	CHEM	132	B	PHY	172	B	PHY
13	C	BIO	53	C	BIO	93	B	CHEM	133	A	PHY	173	D	PHY
14	A	BIO	54	A	BIO	94	C	CHEM	134	C	PHY	174	B	PHY
15	B	BIO	55	C	BIO	95	B	CHEM	135	B	PHY	175	B	PHY
16	C	BIO	56	A	BIO	96	D	CHEM	136	C	PHY	176	C	PHY
17	C	BIO	57	A	BIO	97	B	CHEM	137	B	PHY	177	D	ENG
18	B	BIO	58	B	BIO	98	B	CHEM	138	C	PHY	178	D	ENG
19	A	BIO	59	C	BIO	99	B	CHEM	139	B	PHY	179	D	ENG
20	D	BIO	60	D	BIO	100	B	CHEM	140	B	PHY	180	B	ENG
21	B	BIO	61	B	BIO	101	C	CHEM	141	A	PHY	181	B	ENG
22	C	BIO	62	C	BIO	102	C	CHEM	142	B	PHY	182	C	ENG
23	C	BIO	63	B	BIO	103	B	CHEM	143	C	PHY	183	A	ENG
24	A	BIO	64	B	BIO	104	C	CHEM	144	C	PHY	184	A	ENG
25	A	BIO	65	C	BIO	105	C	CHEM	145	A	PHY	185	A	ENG
26	A	BIO	66	B	BIO	106	B	CHEM	146	C	PHY	186	D	ENG
27	B	BIO	67	A	BIO	107	D	CHEM	147	D	PHY	187	D	ENG
28	A	BIO	68	C	BIO	108	B	CHEM	148	A	PHY	188	C	ENG
29	B	BIO	69	C	CHEM	109	C	CHEM	149	B	PHY	189	A	ENG
30	B	BIO	70	C	CHEM	110	A	CHEM	150	B	PHY	190	A	ENG
31	B	BIO	71	C	CHEM	111	B	CHEM	151	B	PHY	191	D	ENG
32	B	BIO	72	A	CHEM	112	B	CHEM	152	C	PHY	192	A	ENG
33	C	BIO	73	B	CHEM	113	C	CHEM	153	A	PHY	193	C	ENG
34	C	BIO	74	B	CHEM	114	B	CHEM	154	B	PHY	194	B	ENG
35	D	BIO	75	A	CHEM	115	D	CHEM	155	C	PHY	195	A	LOGIC
36	A	BIO	76	B	CHEM	116	B	CHEM	156	D	PHY	196	B	LOGIC
37	B	BIO	77	B	CHEM	117	A	CHEM	157	B	PHY	197	C	LOGIC
38	B	BIO	78	B	CHEM	118	B	CHEM	158	C	PHY	198	B	LOGIC
39	C	BIO	79	B	CHEM	119	C	CHEM	159	A	PHY	199	D	LOGIC
40	B	BIO	80	C	CHEM	120	C	CHEM	160	B	PHY	200	A	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) x 50
- FSc / HSSC Component (40%): (FSc Marks / 1100) x 40
- Matric / SSC Component (10%): (Matric Marks / 1100) x 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: (B)

BIOLOGY
12. Nervous Coordination

Stimuli such as pressure, touch, stretch, and motion stimulate which of the following sensory r...

CORE CONCEPT & DERIVATION

Mechanoreceptors transduce mechanical energy from physical deformation into electrochemical nerve impulses.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Pressure, touch, stretch, and motion represent mechanical displacements of tissue.
- These mechanical forces deform the plasma membrane of mechanoreceptor nerve endings, opening mechanically gated ion channels to trigger action potentials.

Why other options are incorrect:

- **Option A:** Thermoreceptors detect variations in temperature, not mechanical deformation.
- **Option C:** Gustatory receptors detect chemical tastants dissolved in saliva.
- **Option D:** Olfactory receptors detect volatile chemical odorants in the nasal mucosa.

Question #3 Key: (A)

BIOLOGY
01. Cell

A bacterium with a tuft of flagella present at each of its two poles is classified as:

CORE CONCEPT & DERIVATION

Bacterial flagellar arrangements are classified based on the number and spatial distribution of flagella on the cell surface.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In classic bacterial taxonomy and provincial biology textbooks, an amphitrichous bacterium possesses either a single flagellum or a cluster (tuft) of flagella at both opposite poles of the cell.
- This dual polar flagellation allows rapid bidirectional movement.

Why other options are incorrect:

- **Option B:** Monotrichous bacteria possess only a single polar flagellum.
- **Option C:** Lophotrichous bacteria have a tuft of flagella restricted to only one pole.
- **Option D:** Peritrichous bacteria possess flagella distributed uniformly over the entire cell surface.

Question #2 Key: (A)

BIOLOGY
15. Inheritance / Variation & Genetics

The condition where two different alleles of a gene pair are both fully and simultaneously expr...

CORE CONCEPT & DERIVATION

Codominance occurs when both alleles in a heterozygous genotype contribute distinctly and equally to the phenotype without masking each other.

Formula / Rule / Reaction:

$I^A I^B \rightarrow$ Type AB Blood (both A and B antigens present)

Solution:

- In codominance, neither allele is dominant or recessive over the other.
- Both alleles produce functional gene products simultaneously, as exemplified by the MN and ABO blood group systems in humans.

Why other options are incorrect:

- **Option B:** Incomplete dominance produces an intermediate blending of parental phenotypes rather than expressing both distinctly.
- **Option C:** Epistasis is an inter-genic interaction where one gene masks or modifies the phenotypic expression of a gene at a different locus.
- **Option D:** Pleiotropy refers to a single gene influencing multiple distinct phenotypic traits.

Question #4 Key: (C)BIOLOGY
01. Cell

What is the correct sedimentation order of cellular organelles from lowest to highest centrifug...

CORE CONCEPT & DERIVATION

Differential centrifugation separates cellular components based on differences in size and density, with larger and denser organelles pelleting at lower centrifugal speeds.

Formula / Rule / Reaction:

$$\text{Relative Centrifugal Force (RCF)} \propto r\omega^2$$

Solution:

- Nuclei are the largest and densest organelles, pelleting at low speeds (approximately $1,000 \times g$).
- Mitochondria, chloroplasts, and lysosomes are intermediate in size, sedimenting at medium speeds (approximately $10,000 \times g$ to $20,000 \times g$).
- Ribosomes and microsomes are very small, requiring ultracentrifugation speeds (exceeding $100,000 \times g$) to form a pellet.

Why other options are incorrect:

- **Option A:** Inverts the sequence by placing ribosomes before the denser nuclei and mitochondria.
- **Option B:** Incorrectly lists lysosomes as sedimenting before mitochondria and places ribosomes prematurely.
- **Option D:** Incorrectly places mitochondria before nuclei, which are denser and pellet first.

Question #5 Key: (D)BIOLOGY
13. Chemical Coordination

A peptide hormone released from Sertoli cells that selectively inhibits the secretion of follic...

CORE CONCEPT & DERIVATION

Sertoli cells regulate spermatogenesis through negative feedback on the anterior pituitary gland via polypeptide signaling.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Inhibin is a glycoprotein hormone synthesized and secreted by the Sertoli cells of the testes.
- When sperm production reaches sufficient levels, inhibin acts directly on anterior pituitary gonadotrophs to suppress FSH synthesis and secretion without altering LH secretion.

Why other options are incorrect:

- **Option A:** Testosterone is a steroid hormone secreted by Leydig cells that primarily exerts negative feedback on LH and GnRH.
- **Option B:** Gonadotropin-releasing hormone (GnRH) is a hypothalamic decapeptide that stimulates anterior pituitary release of FSH and LH.
- **Option C:** Luteinizing hormone (LH) is an anterior pituitary glycoprotein that stimulates Leydig cells to synthesize testosterone.

Question #6 Key: (B)BIOLOGY
17. Biotechnology

Which protein complex stabilizes the separated single strands of DNA during replication to prev...

CORE CONCEPT & DERIVATION

During replication, DNA helicase unwinds the double helix, and single-stranded binding proteins stabilize the exposed templates.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Single-stranded binding proteins (SSBs) bind cooperatively to exposed single-stranded DNA templates.
- This prevents premature reannealing into a double helix and protects single-stranded regions from degradation by nucleases.

Why other options are incorrect:

- **Option A:** Double-stranded binding proteins interact with intact DNA duplexes and do not stabilize uncoiled single strands at replication forks.
- **Option C:** DNA ligase catalyzes the formation of phosphodiester bonds to join Okazaki fragments on the lagging strand.
- **Option D:** DNA topoisomerase relieves supercoiling and torsional strain ahead of the replication fork by transiently cutting and resealing DNA strands.

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

Which of the following is not an essential requirement for the process of photosynthesis to tak...

CORE CONCEPT & DERIVATION

Photosynthesis utilizes light energy, pigments, and inorganic substrates to synthesize organic molecules, releasing oxygen as a byproduct.

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

- Oxygen (O_2) is an end product released by the photolysis of water in Photosystem II.
- It is not an input reactant needed to initiate or drive photosynthetic reactions.

Why other options are incorrect:

- **Option B:** Chlorophyll pigments are required to absorb photon energy from sunlight.
- **Option C:** Carbon dioxide is the essential carbon source fixed during the Calvin cycle to produce sugars.
- **Option D:** Light energy provides the electromagnetic radiation needed to excite electrons and synthesize ATP and NADPH.

Question #8 Key: (B)BIOLOGY
10. Homeostasis

A natural sponge of which approximate size is capable of filtering an entire residential swimming pool...

CORE CONCEPT & DERIVATION

Sponges (phylum Porifera) are sessile filter feeders that draw large volumes of water through their ostia using flagellated choanocytes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- As described in standard provincial biology textbooks, a basketball-sized natural sponge possesses an extensive canal system.
- It can circulate and filter thousands of liters of water (equivalent to a residential swimming pool) in a single 24-hour period.

Why other options are incorrect:

- Option A:** A tennis ball-sized sponge has insufficient surface area and choanocyte volume to filter that magnitude of water.
- Option C:** A hockey ball-sized sponge does not possess the filtration capacity required for a swimming pool.
- Option D:** A teaspoon-sized sponge filters only tiny quantities of water per day.

Question #9 Key: (A)BIOLOGY
05. Acellular Life

Infectious, misfolded protein particles that cause fatal neurodegenerative diseases in humans are...

CORE CONCEPT & DERIVATION

Prions are proteinaceous infectious particles devoid of any nucleic acid genome that induce conformational changes in native proteins.

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

- Prions convert normal cellular prion protein (PrP^{C}) into an abnormal beta-sheet-rich isoform (PrP^{Sc}).
- This leads to amyloid aggregation and spongiform encephalopathies such as scrapie, bovine spongiform encephalopathy, and Creutzfeldt-Jakob disease.

Why other options are incorrect:

- Option B:** Viroids consist exclusively of small, naked circular single-stranded RNA molecules that infect plants.
- Option C:** A prophage is the latent genome of a temperate bacteriophage integrated into the circular bacterial chromosome.
- Option D:** Bacteriophages are complex viruses composed of nucleic acid enclosed in a protein capsid that infect bacteria.

Question #10 Key: (A)BIOLOGY
03. Enzymes

Daniel Koshland proposed the "Induced Fit Model" of enzyme-substrate interaction in which year?

CORE CONCEPT & DERIVATION

The induced fit model posits that enzyme active sites are flexible and undergo conformational adjustments upon substrate binding.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Daniel E. Koshland Jr. proposed the Induced Fit Model as a modification to Emil Fischer's rigid 1894 Lock and Key Model.
- The Sindh Textbook Board explicitly cites 1959 as the year of this proposal. Note: Some external sources record 1958, but 1959 is the authentic keyed board answer.

Why other options are incorrect:

- Option B:** In 1952, Hershey and Chase confirmed DNA as the genetic material.
- Option C:** 1954 does not correspond to Koshland's enzyme model publication.
- Option D:** 1949 predates the formal formulation of the induced fit concept.

Question #11 Key: (C)BIOLOGY
01. Cell

Ribosomal subunits require which of the following divalent cations to maintain their structural...

CORE CONCEPT & DERIVATION

The association of the small and large ribosomal subunits into a functional 70S or 80S ribosome depends on the ambient concentration of magnesium ions.

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

- Magnesium ions (Mg^{2+}) neutralize the repulsive negative electrostatic charges of the phosphate groups on ribosomal RNA (rRNA).
- They stabilize salt bridges between the rRNA backbone and ribosomal proteins. A drop in Mg^{2+} concentration causes ribosomal dissociation into separate subunits.

Why other options are incorrect:

- Option A:** Calcium ions (Ca^{2+}) function primarily in signal transduction and muscle excitation-contraction coupling, not subunit association.
- Option B:** Ferrous ions (Fe^{2+}) are cofactors for oxygen-carrying heme proteins and electron transport cytochromes.
- Option D:** Zinc ions (Zn^{2+}) act as structural cofactors in zinc finger protein domains and carbonic anhydrase.

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

In sickle cell anemia, hemoglobin fails to carry oxygen properly because glutamic acid is replaced by valine.

CORE CONCEPT & DERIVATION

Sickle cell anemia is an autosomal recessive molecular disorder caused by a single base-pair point mutation in the beta-globin gene.

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

- A point mutation transversion (GAG to GTG) at codon 6 of the β -globin gene substitutes a hydrophilic, negatively charged glutamic acid residue with a hydrophobic, nonpolar valine residue.
- This hydrophobic patch causes deoxy-HbS molecules to polymerize into rigid fibrous strands, deforming erythrocytes into a sickle shape.

Why other options are incorrect:

- Option A:** The 2nd amino acid of the beta chain is histidine, which is unaltered in sickle cell anemia.
- Option C:** The 5th amino acid is proline, which remains unaffected.
- Option D:** The 4th amino acid is threonine, which remains unaffected.

Question #13 Key: (C)BIOLOGY
11. Support & Movement

The accumulation and deposition of hard monosodium urate crystals in synovial joints is diagnostic of...

CORE CONCEPT & DERIVATION

Gouty arthritis is a metabolic disorder of purine metabolism characterized by hyperuricemia and crystal precipitation in articular cartilage.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- When serum uric acid concentrations exceed its physiological solubility limit, needle-shaped monosodium urate crystals deposit in joint spaces.
- This occurs particularly in the metatarsophalangeal joint of the big toe, inciting acute inflammatory responses.

Why other options are incorrect:

- Option A:** Rheumatoid arthritis is an autoimmune condition caused by immune complex deposition and pannus formation, not uric acid crystals.
- Option B:** Osteoarthritis is a degenerative joint disease caused by wear and tear of articular cartilage.
- Option D:** Ankylosing spondylitis is a chronic inflammatory autoimmune disease primarily affecting the sacroiliac joints and axial skeleton.

Question #14 Key: (A)BIOLOGY
17. Biotechnology

Which specialized class of viruses is used in biotechnology to selectively infect, replicate in...

CORE CONCEPT & DERIVATION

Oncolytic virotherapy exploits viruses that selectively propagate within transformed neoplastic cells while sparing normal host tissues.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Oncolytic viruses selectively infect tumor cells due to aberrant antiviral signaling pathways in cancers.
- They replicate intracellularly, induce direct oncolysis, and release tumor antigens that stimulate host antitumor immune responses.

Why other options are incorrect:

- Option B:** Bacteriophages infect bacterial cells exclusively and do not target human neoplastic cells.
- Option C:** Latent proviruses integrate dormant viral DNA into host genomes without causing targeted oncolytic lysis.
- Option D:** Retroviruses reverse-transcribe RNA into DNA and integrate into host genomes, often acting as oncogenic rather than oncolytic agents.

Question #15 Key: (B)BIOLOGY
11. Support & Movement

The red iron-bearing pigment located within muscle sarcoplasm that functions in binding and storing oxygen is...

CORE CONCEPT & DERIVATION

Myoglobin is a monomeric heme protein that serves as an intracellular oxygen reservoir in skeletal and cardiac muscle fibers.

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

- Myoglobin possesses a single polypeptide chain folded around a single iron-protoporphyrin IX heme group.
- It has a higher oxygen affinity than tetrameric hemoglobin, allowing it to release oxygen only under conditions of severe muscular hypoxia.

Why other options are incorrect:

- Option A:** Hemoglobin is a tetrameric transport protein located inside circulating erythrocytes, not inside muscle fibers.
- Option C:** Plasmin is a serine protease enzyme that hydrolyzes fibrin clots during fibrinolysis.
- Option D:** Hemocyanin is a copper-based extracellular oxygen transport protein found in molluscs and arthropods.

Question #16 Key: (C)BIOLOGY
01. Cell

In Gram-negative bacterial cell walls, the peptidoglycan (murein) layer is characteristically:

CORE CONCEPT & DERIVATION

Gram-negative bacterial cell envelopes consist of a thin peptidoglycan layer situated within the periplasmic space between the inner and outer membranes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Gram-negative cell walls contain only a thin peptidoglycan layer (approximately 2 to 7 nm in thickness, representing 5% to 10% of cell wall dry weight).
- This layer is surrounded by an outer membrane rich in lipopolysaccharides, causing Gram-negative cells to decolorize easily and stain pink with safranin.

Why other options are incorrect:

- Option A:** A thick, multi-layered peptidoglycan layer (20 to 80 nm, representing up to 90% of dry weight) is characteristic of Gram-positive bacteria.
- Option B:** Peptidoglycan is present in Gram-negative bacteria; it is absent in organisms like Mycoplasma and Archaea.
- Option D:** The peptidoglycan layer is located beneath the outer lipopolysaccharide membrane, within the periplasm.

Question #17 Key: (C)BIOLOGY
03. Enzymes

Human metabolic enzymes exhibit their highest catalytic activity and optimum reaction rate at a...

CORE CONCEPT & DERIVATION

Enzymes exhibit an optimum temperature at which kinetic molecular energy maximizes effective substrate collisions before thermal denaturation begins.

Formula / Rule / Reaction:

$$\text{Optimum Temperature} \approx 37^{\circ}\text{C} \quad (310 \text{ K})$$

Solution:

- Human enzymes have evolved to function optimally at normal core body temperature (approximately 37°C).
- Above this temperature, hydrogen bonds and ionic interactions maintaining the tertiary protein structure break, leading to thermal denaturation and loss of the catalytic active site.

Why other options are incorrect:

- Option A:** At 15°C, low thermal kinetic energy results in slow intermolecular collision rates and sub-optimal catalytic velocity.
- Option B:** 25°C is room temperature, below the physiological core temperature of humans.
- Option D:** At 55°C, most human globular proteins rapidly denature and lose catalytic activity permanently.

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

Locomotion in segmented worms (phylum Annelida), such as earthworms, is primarily facilitated b...

CORE CONCEPT & DERIVATION

Annelid locomotion utilizes hydrostatic skeleton pressure generated by alternating contractions of muscle layers aided by chitinous bristles.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Segmented annelids utilize chitinous bristles termed setae (or chaetae) embedded in the body wall.
- These anchor segments against the substrate while waves of peristaltic contraction in circular and longitudinal muscles propagate the body forward.

Why other options are incorrect:

- Option A:** Pseudopodia are temporary cytoplasmic extensions used for amoeboid movement in protozoans such as Amoeba.
- Option C:** Flagella are whip-like organelles found in unicellular organisms and spermatozoa.
- Option D:** Ciliated tentacles are feeding structures present in animals such as bryozoans and phoronids.

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

Carbohydrates composed of short chains of 2 to 10 monosaccharide subunits linked by glycosidic ...

CORE CONCEPT & DERIVATION

Oligosaccharides are condensation polymers composed of a defined small number of monosaccharide units (typically 2 to 10).

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Oligosaccharides yield 2 to 10 monosaccharide molecules upon acid or enzymatic hydrolysis.
- Compared to simple monosaccharides, they exhibit reduced water solubility and reduced sweetness, frequently forming glycolipids and glycoproteins on cell membranes.

Why other options are incorrect:

- Option B:** Monosaccharides are simple monomeric sugars (e.g., glucose, fructose) that cannot be further hydrolyzed into smaller carbohydrates.
- Option C:** Polysaccharides are high-molecular-weight macromolecules containing hundreds to thousands of monosaccharide units (e.g., starch, cellulose).
- Option D:** Homopolysaccharides are large polymeric carbohydrates composed of only a single recurring type of monosaccharide monomer.

Question #20 Key: (D)BIOLOGY
17. Biotechnology

Which quantitative laboratory technique measures the absorbance or transmission of specific lig...

CORE CONCEPT & DERIVATION

Spectrophotometry quantifies light absorption by a chemical solution or suspension as described by the Beer-Lambert Law.

Formula / Rule / Reaction:

$$A = \log_{10} \left(\frac{I_0}{I} \right) = \epsilon cl$$

Solution:

- A spectrophotometer passes light of a specific wavelength through a cuvette.
- Turbidity caused by bacterial culture density (optical density at 600 nm), chlorophyll absorption in photosynthesis assays, and nucleic acid concentrations (absorbance at 260 nm) are directly quantified using this technique.

Why other options are incorrect:

- **Option A:** Gel electrophoresis separates charged biomolecules based on size and charge through an agarose or polyacrylamide matrix.
- **Option B:** Paper chromatography separates pigments or solutes based on differential partition coefficients between mobile and stationary phases.
- **Option C:** Micrometry is the microscopic measurement of cellular dimensions using stage and ocular micrometers.

Question #21 Key: (B)BIOLOGY
05. Acellular Life

Which of the following represents a sub-viral infectious agent composed exclusively of a short,...

CORE CONCEPT & DERIVATION

Viroids are autonomous plant pathogens consisting exclusively of catalytic circular naked single-stranded RNA lacking any protein coat.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Discovered by Theodor Diener in 1971, viroids range between 246 and 467 nucleotides of non-coding RNA.
- They cause significant agricultural crop diseases, such as potato spindle tuber disease, by disrupting host transcription through RNA silencing mechanisms.

Why other options are incorrect:

- **Option A:** Prions are infectious agents composed entirely of misfolded protein particles without any nucleic acid.
- **Option C:** Bacteriophages are complete bacterial viruses containing a nucleic acid genome encapsulated by a complex protein coat.
- **Option D:** A virion is a fully assembled, infectious viral particle comprising nucleic acid and an outer protein capsid.

Question #22 Key: (C)BIOLOGY
02. Biomolecules

During digestion in heterotrophic animals, biological macromolecules are split into their const...

CORE CONCEPT & DERIVATION

Digestion is the enzymatic breakdown of complex polymers into absorbable monomers through hydrolysis reactions.

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

- Hydrolytic enzymes (hydrolases, such as amylases, pepsin, trypsin, and lipases) cleave ester, ether, peptide, and glycosidic bonds.
- They do so by introducing hydrogen (H^+) and hydroxyl (OH^-) ions derived from water across the cleaved bond.

Why other options are incorrect:

- **Option A:** Lyases catalyze the cleavage of chemical bonds by means other than hydrolysis or oxidation, often creating double bonds or rings.
- **Option B:** Ligases catalyze the joining of two large molecules coupled with the consumption of an energy-rich phosphate bond from ATP.
- **Option D:** Isomerases catalyze structural or geometric rearrangements within a single molecule without changing its atomic formula.

Question #23 Key: (C)BIOLOGY
12. Nervous Coordination

Animals possessing a ladder-type nervous system, characterized by cerebral ganglia linked to tw...

CORE CONCEPT & DERIVATION

Bilaterally symmetrical acoelomate flatworms exhibit cephalization with a paired longitudinal ladder-like central nervous system.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Phylum Platyhelminthes (e.g., planarians) exhibits an anterior brain composed of bilobed cerebral ganglia.
- From these ganglia, two ventral longitudinal nerve cords extend posteriorly, bridged at regular intervals by transverse commissural nerves, creating a distinct ladder-like architectural pattern.

Why other options are incorrect:

- **Option A:** Porifera (sponges) lack true tissues and have no specialized nervous system or nerve cells.
- **Option B:** Cnidaria (hydra, jellyfish) possess a diffuse, non-polarized nerve net without centralized ganglia.
- **Option D:** Nematoda (roundworms) possess a circumesophageal nerve ring associated with six longitudinal cords, lacking a ladder-type layout.

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

The scientific term "enzyme" (meaning "in yeast") was first coined in 1878 by the German physiologist...

CORE CONCEPT & DERIVATION

The terminology for biological catalysts originated in 19th-century studies of yeast fermentation.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In 1878, Wilhelm Kühne coined the term "enzyme" (derived from the Greek *εν ζυμη*, meaning "in yeast").
- He used this to describe unorganized ferments and non-living chemical agents that catalyze biological transformations.

Why other options are incorrect:

- **Option B:** Eduard Buchner demonstrated cell-free fermentation using yeast extracts in 1897, earning the Nobel Prize in Chemistry.
- **Option C:** Emil Fischer proposed the "Lock and Key" hypothesis of enzyme specificity in 1894.
- **Option D:** J.B.S. Haldane contributed to the mathematical kinetic theory of enzyme catalysis in the 1930s.

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

Which family of ubiquitous, biologically active lipid signaling compounds, derived from arachidonic acid...

CORE CONCEPT & DERIVATION

Prostaglandins are autocrine and paracrine eicosanoids synthesized in virtually all nucleated cells from 20-carbon polyunsaturated fatty acids.

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

- Prostaglandins are lipophilic local hormones produced via the cyclooxygenase pathway.
- They exert localized paracrine effects, modulating platelet aggregation, inflammatory vasodilation, smooth muscle tone, and protective gastric mucus secretion.

Why other options are incorrect:

- **Option B:** Mineralocorticoids (e.g., aldosterone) are endocrine steroid hormones synthesized specifically by the adrenal cortex to regulate renal electrolyte balance.
- **Option C:** Catecholamines (e.g., epinephrine, norepinephrine) are water-soluble amino acid-derived hormones synthesized by the adrenal medulla.
- **Option D:** Glucagon is a polypeptide hormone secreted by pancreatic alpha cells that elevates blood glucose concentrations.

Question #26 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics

Under the conditions of genetic equilibrium in a diploid population, the binomial expansion of...

CORE CONCEPT & DERIVATION

The Hardy-Weinberg law states that allele and genotype frequencies in a large, randomly mating population remain constant across generations in the absence of evolutionary forces.

Formula / Rule / Reaction:

$$(p + q)^2 = p^2 + 2pq + q^2 = 1$$

Solution:

- p^2 represents the frequency of the homozygous dominant genotype (AA).
- $2pq$ represents the frequency of the heterozygous genotype (Aa).
- q^2 represents the frequency of the homozygous recessive genotype (aa).
- The sum of all genotype frequencies in a population must equal 1 (100%).

Why other options are incorrect:

- **Option B:** Omits the coefficient 2 for the heterozygous class, failing the binomial square expansion.
- **Option C:** Incorrectly multiplies terms by linear coefficients instead of squaring allele frequencies.
- **Option D:** Equates total frequency to 0 rather than unity (1).

Question #27 Key: (B)BIOLOGY
17. Biotechnology

In his classic plant tissue culture experiments demonstrating cellular totipotency, F.C. Steward...

CORE CONCEPT & DERIVATION

Cellular totipotency is the inherent ability of a single differentiated vegetative plant cell to regenerate into an entire functional organism.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In 1958, F.C. Steward isolated free, differentiated phloem explant cells from mature cultivated carrot roots (*Daucus carota*).
- When cultured in a liquid nutrient medium supplemented with coconut milk, these cells divided to form embryoids that successfully grew into fertile mature carrot plants.

Why other options are incorrect:

- **Option A:** Radish was not used in Steward's original totipotency regeneration experiments.
- **Option C:** Maize was utilized extensively in Barbara McClintock's transposon genetic studies, not Steward's experiments.
- **Option D:** Garden peas were used by Gregor Mendel in his classic hybridization and inheritance experiments.

Question #28 Key: (A)BIOLOGY
02. Biomolecules

The core histone octamer proteins responsible for DNA packaging into nucleosomes are characteri...

CORE CONCEPT & DERIVATION

Histones form the protein spool around which negatively charged eukaryotic DNA wraps to form chromatin fibers.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Histones contain high proportions (over 20%) of the basic, positively charged amino acids lysine and arginine.
- At physiological pH, their positively charged amino side chains form strong ionic salt bridges with the negatively charged phosphodiester backbone of DNA.

Why other options are incorrect:

- **Option B:** Acidic amino acids (aspartic acid, glutamic acid) carry negative charges and would electrostatically repel DNA.
- **Option C:** Aromatic amino acids (phenylalanine, tyrosine, tryptophan) provide nonpolar hydrophobic bulk rather than electrostatic DNA binding.
- **Option D:** Sulfur-containing amino acids (cysteine, methionine) are involved in disulfide crosslinking and translation initiation, not electrostatic chromatin packaging.

Question #29 Key: (B)BIOLOGY
14. Reproduction

In the human male reproductive system, the primary anatomic site where newly formed spermatozoa...

CORE CONCEPT & DERIVATION

Immature spermatozoa leaving the seminiferous tubules are non-motile and infertile; functional maturation occurs along the epididymal duct.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Spermatozoa pass into the caput, corpus, and cauda of the epididymis over a period of 10 to 14 days.
- In the epididymis, sperm cells undergo maturation, develop forward motility, stabilize their acrosomal membranes, and remain stored in the cauda epididymis until ejaculation.

Why other options are incorrect:

- **Option A:** Seminal vesicles are accessory glands that produce an alkaline fluid containing fructose, ascorbic acid, and prostaglandins.
- **Option C:** The prostate gland secretes a milky, slightly acidic fluid containing citric acid and proteolytic enzymes.
- **Option D:** The vasa deferentia are muscular ducts that transport sperm from the epididymis to the ejaculatory duct during emission.

Question #30 Key: (B)BIOLOGY
14. Reproduction

A clinical condition in human males characterized by the complete and total absence of spermato...

CORE CONCEPT & DERIVATION

Male infertility disorders are classified according to specific quantitative and qualitative semen parameter abnormalities.

Formula / Rule / Reaction:

$$\text{Sperm Count} = 0 \text{ spermatozoa/mL} \Rightarrow \text{Azoospermia}$$

Solution:

- Azoospermia is defined as zero detectable sperm in the semen centrifuge pellet on at least two separate occasions.
- This results either from non-obstructive spermatogenic failure or obstructive ductal blockages.

Why other options are incorrect:

- **Option A:** Oligospermia is a condition where the sperm count is abnormally low (less than 15×10^6 sperm/mL), but not absent.
- **Option C:** Asthenozoospermia refers to reduced or defective progressive sperm motility.
- **Option D:** Teratozoospermia refers to an abnormally high percentage of morphologically abnormal spermatozoa.

Question #31 Key: (B)BIOLOGY
04. Bioenergetics

Which specialized aerobic chemoautotrophic bacterial species is capable of oxidizing toxic carb...

CORE CONCEPT & DERIVATION

Carboxydophilic bacteria utilize carbon monoxide dehydrogenase enzymes to couple CO oxidation with respiration and autotrophic growth.

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

- *Bacillus oligocarbophilus* (also classified as *Pseudomonas* species in older textbook revisions) contains a molybdenum-containing carbon monoxide dehydrogenase.
- This enzyme oxidizes CO to CO₂, playing a key role in the global carbon cycle.

Why other options are incorrect:

- **Option A:** *Hydrogenomonas* bacteria oxidize molecular hydrogen (H₂) rather than carbon monoxide.
- **Option C:** *Thiobacillus* species oxidize inorganic sulfur compounds (such as hydrogen sulfide and thiosulfate) into sulfate.
- **Option D:** *Azotobacter* is a free-living, heterotrophic nitrogen-fixing bacterium that reduces N₂ into ammonia.

Question #32 Key: (B)BIOLOGY
01. Cell

The primary constricted chromosomal locus that holds two replicated sister chromatids together ...

CORE CONCEPT & DERIVATION

The centromere is a specialized heterochromatic DNA region necessary for chromosome segregation during mitosis and meiosis.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The centromere maintains cohesion between replicated sister chromatids via cohesin protein complexes until anaphase.
- It directs the assembly of the proteinaceous kinetochore, where spindle microtubules attach to exert pulling tension.

Why other options are incorrect:

- **Option A:** The centrosome is the primary microtubule-organizing center of animal cells containing a pair of centrioles.
- **Option C:** The telomere is the repetitive nucleotide cap located at the ends of linear eukaryotic chromosomes that protects against degradation.
- **Option D:** A nucleosome is the fundamental repeating subunit of chromatin, consisting of 146 base pairs of DNA wrapped around a histone octamer.

Question #33 Key: (C)BIOLOGY
07. Circulation / Transport

The most widely accepted physical theory explaining the continuous upward ascent of sap through...

CORE CONCEPT & DERIVATION

The cohesion-tension mechanism proposed by Dixon and Joly explains sap ascent through uninterrupted hydraulic columns under negative pressure.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- As water evaporates from mesophyll cells during transpiration, a steep negative water potential gradient (transpiration pull) is established.
- Due to strong hydrogen bonding between water molecules (cohesion) and attractions between water and xylem cell walls (adhesion), a continuous column of sap is drawn upward without cavitation.

Why other options are incorrect:

- **Option A:** Root pressure is an active positive hydrostatic pressure that rarely exceeds 0.2 MPa, insufficient to drive sap to the canopy of tall trees.
- **Option B:** Capillarity accounts for only a minimal rise of water (less than 1 meter) in narrow vessels.
- **Option D:** Atmospheric pressure can support a vertical column of water to a maximum height of only approximately 10.3 meters.

Question #34 Key: (C)BIOLOGY
10. Homeostasis

Plants that possess extensive aerenchyma tissue containing large interconnected air spaces are ...

CORE CONCEPT & DERIVATION

Aerenchyma is specialized spongy parenchymatous tissue with continuous air channels that facilitate internal gas diffusion in submerged organs.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Hydrophytes (water plants) inhabit oxygen-depleted, water-saturated aquatic environments.
- Aerenchyma provides low-resistance internal gas conduits to transport oxygen from aerial parts down to submerged roots while imparting structural buoyancy to float leaves.

Why other options are incorrect:

- **Option A:** Xerophytes adapt to arid environments by developing thick cuticles, sunken stomata, and water-storing succulent parenchyma, not aerenchyma.
- **Option B:** Mesophytes inhabit moderate environments with well-aerated soils and standard intercellular spongy mesophyll.
- **Option D:** Halophytes inhabit saline environments and adapt by accumulating organic osmoprotectants and salt-secreting glands.

Question #35 Key: (D)BIOLOGY
02. Biomolecules

According to Chargaff's rules of base pairing in double-stranded DNA, if one strand contains an...

CORE CONCEPT & DERIVATION

Complementary base pairing in antiparallel DNA duplexes is dictated by specific hydrogen-bonding geometries between purines and pyrimidines.

Formula / Rule / Reaction:

Adenine (A) = Thymine (T) (2 Hydrogen Bonds)

Guanine (G) = Cytosine (C) (3 Hydrogen Bonds)

Solution:

- Adenine forms two specific hydrogen bonds with thymine across the double helix.
- Thus, an adenine nucleotide on one polynucleotide strand always pairs with a thymine nucleotide on the opposite strand.

Why other options are incorrect:

- **Option A:** Uracil is the pyrimidine base that pairs with adenine in RNA molecules, not in DNA.
- **Option B:** Cytosine is a pyrimidine that specifically forms three hydrogen bonds with guanine.
- **Option C:** Guanine is a purine that pairs with cytosine.

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

Progeny bacteriophages escape from and lyse their bacterial host cell at the conclusion of the ...

CORE CONCEPT & DERIVATION

Phage-mediated host lysis requires degradation of the bacterial peptidoglycan cell wall by a phage-encoded endolysin.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Late in the lytic reproductive cycle, the bacteriophage genome directs the synthesis of lysozyme (phage endolysin).
- This enzyme hydrolyzes the $\beta(1 \rightarrow 4)$ glycosidic bonds between N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM) in the bacterial peptidoglycan wall, causing osmotic lysis.

Why other options are incorrect:

- **Option B:** General proteases degrade peptide chains and do not target the glycan polysaccharide backbone of the cell wall.
- **Option C:** Amylase hydrolyzes $\alpha(1 \rightarrow 4)$ glucosidic linkages in plant starch and animal glycogen.
- **Option D:** Lipase hydrolyzes ester linkages in triglycerides and does not disrupt bacterial murein sacculi.

Question #37 Key: (B)BIOLOGY
14. Reproduction

Which of the following soft-bodied invertebrates is characteristically described as ambisexual ...

CORE CONCEPT & DERIVATION

Ambisexual (monoecious or hermaphroditic) organisms possess both functional male (testes) and female (ovaries) gonads in the same individual.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The earthworm is a classic textbook hermaphroditic animal possessing two pairs of testes in segments 10 and 11 and a pair of ovaries in segment 13.
- While mutual cross-fertilization is practiced, each individual possesses the complete anatomical structures of both sexes simultaneously.

Why other options are incorrect:

- **Option A:** Tapeworms are endoparasitic flatworms composed of successive reproductive proglottids.
- **Option C:** Many terrestrial snails are hermaphrodites, but dioecious species also exist widely.
- **Option D:** Oysters exhibit sequential hermaphroditism (protandry), alternating their sex over seasons rather than maintaining simultaneous bilateral organs.

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

In human dentition, the total count of deciduous (milk) teeth and permanent teeth is, respectiv...

CORE CONCEPT & DERIVATION

Humans exhibit diphyodont dentition, producing two successive sets of teeth throughout life: deciduous and permanent dentition.

Formula / Rule / Reaction:

$$\text{Deciduous Dental Formula: } \frac{2.1.0.2}{2.1.0.2} \times 2 = 20$$

$$\text{Permanent Dental Formula: } \frac{2.1.2.3}{2.1.2.3} \times 2 = 32$$

Solution:

- The primary deciduous set contains 20 teeth (8 incisors, 4 canines, and 8 molars; premolars are absent).
- The permanent adult dentition contains 32 teeth (8 incisors, 4 canines, 8 premolars, and 12 molars, including third molars or wisdom teeth).

Why other options are incorrect:

- **Option A:** Underestimates the deciduous count by 2 teeth.
- **Option C:** Overestimates deciduous teeth by 4.
- **Option D:** Omits the 4 third molars (wisdom teeth) from the permanent set.

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

Which anterior pituitary gonadotropic hormone triggers ovulation and stimulates the conversion ...

CORE CONCEPT & DERIVATION

The mid-cycle surge of luteinizing hormone (LH) triggers follicular rupture and subsequent luteinization of the granulosa and theca cells.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- A sudden mid-cycle peak in estrogen levels stimulates positive feedback on the pituitary, generating an LH surge.
- This surge triggers the release of the secondary oocyte (ovulation) and induces the collapsed follicle to transform into a yellowish endocrine gland, the corpus luteum, which secretes progesterone.

Why other options are incorrect:

- **Option A:** Follicle-stimulating hormone (FSH) promotes early antral follicular growth and estrogen secretion by granulosa cells.
- **Option B:** Adrenocorticotropic hormone (ACTH) stimulates glucocorticoid secretion from the adrenal cortex.
- **Option D:** Thyroid-stimulating hormone (TSH) promotes the synthesis and secretion of thyroid hormones from the thyroid gland.

Question #40 Key: (B)BIOLOGY
05. Acellular Life

When the viral genome of a temperate bacteriophage is integrated stably into the circular bacte...

CORE CONCEPT & DERIVATION

Temperate bacteriophages can undergo a lysogenic cycle where the viral DNA recombines into the host bacterial chromosome.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- During lysogeny, the linear phage DNA circularizes upon host entry and integrates into a specific bacterial attachment site via viral integrase.
- This dormant, integrated viral DNA genome is called a prophage and replicates along with the host chromosome without causing lysis.

Why other options are incorrect:

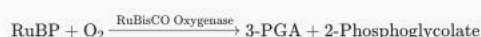
- **Option A:** A viroid is an infectious circular non-coding RNA molecule that infects higher plants.
- **Option C:** A prion is a misfolded, infectious protein that causes neurodegenerative spongiform encephalopathies.
- **Option D:** A capsomere is an individual protein subunit that associates with others to form the outer viral capsid.

Question #41 Key: (A)BIOLOGY
04. Bioenergetics

The light-dependent process in which [Formula] plants consume oxygen and release carbon dioxide...

CORE CONCEPT & DERIVATION

Photorespiration occurs when the bifunctional enzyme RuBisCO binds molecular oxygen instead of carbon dioxide, initiating an energy-consuming salvage pathway.

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

- In high O_2/CO_2 ratios and warm temperatures, RuBisCO oxygenates ribulose-1,5-bisphosphate (RuBP).
- The resulting 2-phosphoglycolate is metabolized through chloroplasts, peroxisomes, and mitochondria to yield 3-PGA, with loss of fixed carbon as CO_2 and no production of ATP.

Why other options are incorrect:

- **Option B:** Oxidative phosphorylation is the mitochondrial process that produces ATP using energy derived from electron transfer to oxygen.
- **Option C:** Cyclic photophosphorylation is a light-driven photosynthetic pathway that produces ATP without generating NADPH or evolving oxygen.
- **Option D:** Lactic acid fermentation is an anaerobic cytosolic process that regenerates NAD^+ by reducing pyruvate to lactate.

Question #42 Key: (A)BIOLOGY
12. Nervous Coordination

A sufficient depolarization of the axolemma (neuronal cell membrane) that reaches the firing th...

CORE CONCEPT & DERIVATION

Depolarization exceeding the threshold potential triggers the all-or-none opening of voltage-gated sodium channels, initiating an action potential.

Formula / Rule / Reaction:

$$V_m \geq -55 \text{ mV (Threshold)} \implies \text{Action Potential Generation}$$

Solution:

- When excitatory postsynaptic potentials depolarize the initial axon segment to its threshold (approximately -55 mV), voltage-gated Na^+ channels open rapidly.
- The influx of Na^+ depolarizes the membrane toward $+30 \text{ mV}$, firing a propagating action potential.

Why other options are incorrect:

- **Option B:** Inhibitory postsynaptic potentials (IPSPs) cause hyperpolarization of the membrane away from threshold.
- **Option C:** The resting membrane potential is the baseline polarized state (approximately -70 mV) maintained by the sodium-potassium pump.
- **Option D:** Sub-threshold potentials are graded local potentials that fail to reach firing threshold and decay passively.

Question #43 Key: (D)BIOLOGY
16. Evolution

The deliberate cross-breeding of two genetically dissimilar or distinct parent varieties throug...

CORE CONCEPT & DERIVATION

Plant and animal breeding utilizes hybridization to combine superior traits from divergent parents to obtain hybrid vigor (heterosis).

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Hybridization is the process of interbreeding individuals from genetically different strains, varieties, or species.
- Artificial pollination ensures the transfer of pollen from the anther of one parent to the receptive stigma of the other to produce hybrid offspring.

Why other options are incorrect:

- **Option A:** Acclimatization is the gradual physiological adjustment of an individual organism to environmental changes during its lifetime.
- **Option B:** Backcrossing is the mating of an F_1 hybrid offspring with one of its original parental genotypes.
- **Option C:** Inbreeding is the mating of closely related individuals over successive generations, which increases homozygosity.

Question #44 Key: (C)BIOLOGY
02. Biomolecules

In flowering vascular plants (angiosperms), photosynthetic assimilates are translocated through...

CORE CONCEPT & DERIVATION

Carbohydrates are transported through phloem sieve tube elements as non-reducing, highly soluble disaccharides to minimize unwanted chemical reactivity.

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

- Sucrose is an unreactive, non-reducing disaccharide that dissolves at high concentrations.
- It moves without reacting prematurely with cellular enzymes or intermediate metabolites during long-distance bulk flow from source leaves to sinks.

Why other options are incorrect:

- **Option A:** Starch is an insoluble branched polysaccharide utilized exclusively for long-term carbohydrate storage, not vascular translocation.
- **Option B:** Glucose is a reducing monosaccharide metabolized directly in glycolysis and would be too chemically reactive for vascular transport.
- **Option D:** Fructose is an active ketohexose monosaccharide that is converted to sucrose prior to phloem loading.

Question #45 Key: (B)BIOLOGY
04. Bioenergetics

The linear electron transport pathway of the light-dependent reactions of photosynthesis involv...

CORE CONCEPT & DERIVATION

Non-cyclic photophosphorylation traces a characteristic zigzag energy diagram termed the Z-scheme based on the redox potentials of electron carriers.

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

- In non-cyclic photophosphorylation, light energizes electrons in PS II, which cascade through plastoquinone, cytochrome b_6f , and plastocyanin to PS I.
- A second photon excitation boosts electrons to ferredoxin, reducing NADP^+ to NADPH. Plotted on a redox potential scale, this zigzag pathway resembles the letter "Z".

Why other options are incorrect:

- **Option A:** The Calvin-Benson cycle represents the light-independent stromal reactions that fix carbon dioxide into triose sugars.
- **Option C:** The Krebs cycle is the mitochondrial matrix pathway that oxidizes acetyl-CoA into carbon dioxide, generating NADH and FADH_2 .
- **Option D:** The Embden-Meyerhof pathway is the cytosolic glycolytic sequence that converts glucose into pyruvate.

Question #46 Key: (B)BIOLOGY
17. Biotechnology

In gel electrophoresis, negatively charged nucleic acid molecules migrate through the agarose m...

CORE CONCEPT & DERIVATION

Electrophoresis is the migration of charged colloidal particles or macromolecules under the influence of an applied electric field.

Formula / Rule / Reaction:

$$v = \frac{qE}{f}$$

Solution:

- DNA and RNA molecules carry uniform negative charges along their phosphodiester backbones.
- When an electric potential difference (E) is applied across the buffer-submerged gel, the negatively charged nucleic acids migrate toward the positive electrode (anode) at rates inversely proportional to their molecular size.

Why other options are incorrect:

- Option A:** The agar concentration determines the pore size of the molecular sieve, but does not provide the motive force for migration.
- Option C:** Osmotic pressure gradients drive the bulk movement of water solvent across semipermeable membranes, not macromolecules in electrophoresis.
- Option D:** Active transport refers to protein carrier-mediated, ATP-dependent transport across biological lipid bilayers.

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

In simple carbohydrates (hydrates of carbon), hydrogen and oxygen atoms are typically present i...

CORE CONCEPT & DERIVATION

Carbohydrates were historically defined as hydrates of carbon based on their empirical formula containing hydrogen and oxygen in the same ratio as water.

Formula / Rule / Reaction:



Solution:

- In simple monosaccharides like glucose ($C_6H_{12}O_6$) and ribose ($C_5H_{10}O_5$), the hydrogen and oxygen atoms exist in an exact 2:1 ratio.
- This matches the stoichiometric ratio found in pure water.

Why other options are incorrect:

- Option B:** A 1:1 ratio does not correspond to carbohydrate stoichiometry.
- Option C:** A 3:1 ratio has excess hydrogen and does not occur in standard carbohydrates.
- Option D:** A 1:2 ratio inverts the hydrogen to oxygen ratio.

Question #48 Key: (C)BIOLOGY
04. Bioenergetics

Which group of lipid-soluble accessory photosynthetic pigments is present in both plants and th...

CORE CONCEPT & DERIVATION

Carotenoids are isoprenoid pigments synthesized by plants that are acquired by animals through diet to support visual and antioxidant physiology.

Formula / Rule / Reaction:



Solution:

- Carotenoids (carotenes and xanthophylls) absorb blue-violet light and protect chlorophyll from photo-oxidation in plants.
- In humans, ingested β -carotene is enzymatically cleaved into retinal, the essential chromophore in rhodopsin for rod cell photoreception, and lutein/zeaxanthin protect the retinal macula.

Why other options are incorrect:

- Option A:** Chlorophylls are magnesium-porphyrin complexes present exclusively in photosynthetic autotrophs and are not found in human tissues.
- Option B:** Phycobilins are water-soluble bile pigment chromophores present in cyanobacteria and red algae.
- Option D:** Anthocyanins are water-soluble flavonoid vacuolar pigments that impart red, purple, and blue colors to plant flowers and fruits.

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

The genetic phenomenon where multiple non-allelic gene pairs at different chromosomal loci infl...

CORE CONCEPT & DERIVATION

Polygenic inheritance (quantitative inheritance) involves continuous phenotypic variation produced by the cumulative additive effects of multiple independent genes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In traits such as human skin pigmentation, height, and wheat kernel color, two or more separate gene pairs located at different loci contribute quantitatively to the phenotype.
- Each dominant allele exerts an incremental additive effect on the physical trait.

Why other options are incorrect:

- **Option A:** Codominance involves the distinct, equal expression of two alternative alleles of the same single gene locus in a heterozygote.
- **Option C:** Incomplete dominance is a monogenic interaction where a heterozygote displays a phenotype intermediate between two homozygous parents.
- **Option D:** Multiple allelism refers to the existence of three or more alternative allele forms of a single gene within a population (e.g., ABO blood group).

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

The biophysical laboratory method used to isolate and separate individual cellular organelles a...

CORE CONCEPT & DERIVATION

Cell fractionation separates subcellular organelles while preserving their biochemical and enzymatic functions.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Cell fractionation consists of two primary sequential steps: homogenization (disrupting plasma membranes in cold, isotonic buffer) followed by differential centrifugation.
- Spinning at successively higher speeds pellets organelles from largest and densest to smallest.

Why other options are incorrect:

- **Option A:** Chromatography is a chemical separation technique based on differential partition between stationary and mobile phases, typically used for small molecules or proteins.
- **Option C:** Microdissection is the mechanical isolation of specific cells or histological structures under microscopic visualization.
- **Option D:** Spectrophotometry is an analytical method that measures light absorption to quantify solute concentration, not to isolate intact organelles.

Question #51 Key: (D)BIOLOGY
15. Inheritance / Variation & Genetics

The type of cancer common in young men between the ages of 15 and 34 that has a high cure rate...

CORE CONCEPT & DERIVATION

Testicular cancer is the most prevalent solid malignancy in young adult males, exhibiting exceptional sensitivity to platinum-based chemotherapy and surgical resection.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Testicular germ cell tumors most commonly affect males aged 15 to 34 years.
- When detected at early clinical stages, testicular cancer boasts cure rates exceeding 95% using radical orchiectomy and adjuvant chemotherapy.

Why other options are incorrect:

- **Option A:** Non-melanoma skin cancer occurs predominantly in older individuals following decades of cumulative ultraviolet radiation exposure.
- **Option B:** Lung cancer occurs primarily in older adults with extended histories of tobacco smoking and carries a lower cure rate.
- **Option C:** Blood cancers (leukemias and lymphomas) show variable incidence across childhood and older age brackets, with differing prognostic profiles.

Question #52 Key: (C)BIOLOGY
17. Biotechnology

This process inhibits the metabolism and growth of anaerobic microbes used for the treatment of...

CORE CONCEPT & DERIVATION

Obligate anaerobes lack protective enzymes against reactive oxygen species, making oxygen at high partial pressures directly cytotoxic to them.

Formula / Rule / Reaction:

High $pO_2 \Rightarrow$ Accumulation of Superoxide ($O_2^{\cdot -}$) and $H_2O_2 \Rightarrow$ Lysis of Anaerob

Solution:

- Gas gangrene is caused by obligate anaerobic spore-forming bacilli, predominantly *Clostridium perfringens*.
- Hyperbaric oxygen therapy (HBOT) delivers 100% oxygen at pressures between 2 and 3 atmospheres. This saturates deep necrotic tissues with dissolved oxygen, inactivating clostridial alpha-toxin production and killing vegetative anaerobic cells.

Why other options are incorrect:

- **Option A:** Desiccation removes moisture but fails to eliminate resistant bacterial endospores produced by *Clostridium* species.
- **Option B:** Ionizing radiation is utilized for sterilizing medical supplies, not as an in vivo clinical therapy for deep tissue infections.
- **Option D:** Lyophilization (freeze-drying) preserves bacterial viability for long-term laboratory storage rather than eliminating it.

Question #53 Key: (C)BIOLOGY
11. Support & Movement

The branching network-like arrangement of cardiac muscles is called:

CORE CONCEPT & DERIVATION

Cardiac muscle fibers form an interconnected physiological syncytium coupled by intercalated discs containing gap junctions.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Cardiac myocytes are branched, uninucleated cells connected end-to-end via intercalated discs.
- Low-resistance gap junctions within these discs permit rapid ion diffusion and electrical coupling between adjacent cells, allowing the entire atrial or ventricular myocardium to contract as a coordinated single functional syncytium.

Why other options are incorrect:

- **Option A:** The epimysium is an external sheath of dense irregular connective tissue that surrounds an entire skeletal muscle belly.
- **Option B:** The sarcolemma is the specialized plasma membrane enclosing an individual muscle fiber.
- **Option D:** The perimysium is a layer of connective tissue that groups individual muscle fibers into fascicles.

Question #54 Key: (A)BIOLOGY
03. Enzymes

Molecules that bind to an enzyme away from the active site and increase the function of that ac...

CORE CONCEPT & DERIVATION

Allosteric modulation occurs when an effector binds reversibly to a non-catalytic site, inducing conformational shifts that alter catalytic efficiency.

Formula / Rule / Reaction:

Enzyme (T-state) + Allosteric Activator $\rightleftharpoons$ Enzyme-Activator Complex (R-state)

Solution:

- Allosteric enzymes possess regulatory sites distinct from the catalytic active site.
- Binding of an allosteric activator stabilizes the high-affinity relaxed (R) conformation of the enzyme, increasing its affinity for substrate and enhancing reaction velocity.

Why other options are incorrect:

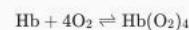
- **Option B:** Allosteric inhibitors bind to allosteric sites and stabilize the low-affinity tense (T) state, decreasing catalytic activity.
- **Option C:** Competitive inhibitors bind directly to the active site itself in competition with the substrate.
- **Option D:** Coenzymes are organic non-protein carrier molecules (e.g., NAD⁺, FAD) that participate directly in chemical group transfers during catalysis.

Question #55 Key: (C)BIOLOGY
02. Biomolecules

The maximum number of oxygen molecules that can be transported by one hemoglobin molecule is:

CORE CONCEPT & DERIVATION

Adult hemoglobin (HbA) is a tetrameric hemoprotein containing four prosthetic heme groups capable of binding oxygen reversibly.

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

- A molecule of adult hemoglobin is composed of four polypeptide subunits (two alpha and two beta chains).
- Each subunit contains a central iron-protoporphyrin IX (heme) moiety with an Fe²⁺ atom that reversibly coordinates one diatomic oxygen (O₂) molecule. Thus, one complete hemoglobin tetramer binds up to 4 oxygen molecules (8 oxygen atoms).

Why other options are incorrect:

- **Option A:** 1 oxygen molecule is the binding capacity of monomeric myoglobin, not tetrameric hemoglobin.
- **Option B:** 2 oxygen molecules represents 50% oxygen saturation of hemoglobin.
- **Option D:** 6 oxygen molecules exceeds the structural stoichiometry of hemoglobin's four coordination sites.

Question #56 Key: (A)BIOLOGY
10. Homeostasis

The top milk-producing dairy animal breed is:

CORE CONCEPT & DERIVATION

Selective dairy breeding in Pakistan has developed high-yielding riverine buffalo breeds renowned for high lactation output.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The Nili-Ravi buffalo breed, native to the fertile valleys of the Sutlej and Ravi rivers in Punjab, is widely recognized as the premier dairy buffalo breed.
- It produces between 2,000 and 2,500 liters of milk per lactation with high butterfat content (over 6.5%), outperforming other domestic breeds.

Why other options are incorrect:

- **Option B:** Bhadawari is an Indian buffalo breed noted for high butterfat percentage but significantly lower total lactation volume.
- **Option C:** Sahiwal is an elite zebu cattle breed, but its average lactation yield is lower than that of top-tier Nili-Ravi buffaloes.
- **Option D:** Red Sindhi is a indigenous dairy cattle breed adapted to arid climates, yielding less total milk than Nili-Ravi.

Question #57 Key: (A)BIOLOGY
02. Biomolecules

Which of the following is the direct precursor for the biosynthesis of steroid hormones such as...

CORE CONCEPT & DERIVATION

Steroidogenesis involves the enzymatic conversion of a 27-carbon sterol core into mineralocorticoids, glucocorticoids, and sex steroids.

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

- Cholesterol serves as the parent molecule for all vertebrate steroid hormones.
- In the mitochondria of steroidogenic cells, cholesterol undergoes side-chain cleavage by desmolase to yield pregnenolone, which is subsequently converted into progesterone, testosterone, estradiol, cortisol, and aldosterone.

Why other options are incorrect:

- Option B:** Choline is an essential water-soluble nutrient required for the synthesis of acetylcholine and membrane phosphatidylcholine.
- Option C:** Phosphatidylcholine is a major phospholipid component of cellular lipid bilayers.
- Option D:** Glycerol is a three-carbon polyol that forms the structural backbone of triacylglycerols and glycerophospholipids.

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

A neural cable extending from the brainstem down through the backbone and enclosed within the v...

CORE CONCEPT & DERIVATION

The central nervous system consists of the encephalon (brain) and the medulla spinalis (spinal cord) housed within bony skeletal cavities.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The spinal cord is a cylindrical bundle of nerve tissue and neuroglia extending from the medulla oblongata at the foramen magnum down to the lumbar region (L1/L2).
- It is protected inside the vertebral canal by the bony vertebrae, cerebrospinal fluid, and meninges.

Why other options are incorrect:

- Option A:** The meninges are three protective connective tissue membranes (dura, arachnoid, and pia mater) that envelop the brain and spinal cord.
- Option C:** An axon is a long, slender microscopic projection of a single neuron that conducts electrical impulses away from the cell body.
- Option D:** The cauda equina is the collection of spinal nerve roots descending below the conus medullaris in the lower vertebral canal.

Question #59 Key: (C)BIOLOGY
14. Reproduction

Which of the following accurately describes the morphology and motility of *Helicobacter pylori* ...

CORE CONCEPT & DERIVATION

Helicobacter pylori is a microaerophilic, spiral-shaped bacterium that colonizes the gastric mucosa using specialized polar flagella.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Helicobacter pylori* is a Gram-negative bacterium exhibiting a distinctive helical or spiral morphology.
- It possesses multiple unipolar (lophotrichous) sheathed flagella that generate corkscrew-like motility, allowing the organism to burrow through the viscous gastric mucus layer.

Why other options are incorrect:

- Option A:** *H. pylori* is spiral rather than straight rod-shaped, and it is actively motile via flagella.
- Option B:** *H. pylori* occurs as solitary curved spirals rather than long linear chains (which is characteristic of *Streptococcus*).
- Option D:** *H. pylori* is not a non-motile spherical coccus.

Question #60 Key: (D)BIOLOGY
02. Biomolecules

Water has a very high specific heat of vaporization of approximately:

CORE CONCEPT & DERIVATION

The high heat of vaporization of liquid water results from the extensive network of intermolecular hydrogen bonds that must be broken to transition into steam.

Formula / Rule / Reaction:

$$\Delta H_v \approx 540 \text{ cal/g} = 540 \text{ kcal/kg} \quad (\text{At } 100^\circ\text{C})$$

$$\Delta H_v \approx 574 \text{ to } 580 \text{ kcal/kg} \quad (\text{At physiological } 25^\circ\text{C to } 37^\circ\text{C})$$

Solution:

- In standard provincial biology textbooks, the heat of vaporization of water is recorded as approximately 574 kcal/kg (or 574 cal/g at physiological temperatures).
- This property enables evaporative cooling through perspiration and transpiration, buffering organisms against thermal fluctuations.

Why other options are incorrect:

- Option A:** 274 kcal/kg underestimates the energy required to break hydrogen bonds in water by more than half.
- Option B:** 374 kcal/kg is numerically inaccurate for the heat of vaporization of water.
- Option C:** 474 kcal/kg fails to reach the accepted textbook constant of 574 kcal/kg.

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

Which specialized mature cells are embedded within lacunae and are responsible for maintaining ...

CORE CONCEPT & DERIVATION

Cartilage is an avascular connective tissue composed of specialized cells embedded within an extracellular gel rich in glycosaminoglycans and collagen.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Chondroblasts secrete the surrounding extracellular matrix and subsequently mature into chondrocytes.
- Chondrocytes reside isolated within small cavities called lacunae and maintain the collagen fibers and proteoglycans that give cartilage its resilience.

Why other options are incorrect:

- **Option A:** Osteocytes are mature bone cells situated within lacunae of mineralized bone matrix.
- **Option C:** Fibroblasts are spindle-shaped cells that synthesize collagen and ground substance in loose and dense proper connective tissue.
- **Option D:** Osteoblasts are active bone-forming cells that secrete unmineralized bone matrix (osteoid).

Question #62 Key: (C)BIOLOGY
12. Nervous Coordination

Emotional behavioral responses, particularly fear, rage, and defensive behavior, are primarily ...

CORE CONCEPT & DERIVATION

The limbic system coordinates emotions and motivational drives, with the amygdaloid nuclei serving as the critical hub for affective processing.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The amygdala is an almond-shaped complex of nuclei located in the anterior temporal lobe.
- It processes sensory inputs related to danger and orchestrates emotional behavioral responses such as fear conditioning, aggression, and autonomic fight-or-flight signaling.

Why other options are incorrect:

- **Option A:** The pituitary gland is a master endocrine organ that secretes systemic trophic hormones under hypothalamic control.
- **Option B:** The cerebellum coordinates motor movements, balance, and procedural motor learning.
- **Option D:** The hippocampus functions primarily in the consolidation of short-term memory into long-term declarative memory and spatial navigation.

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

In skeletal muscle fibers, which transverse tubular system runs perpendicularly from the sarcolemma...

CORE CONCEPT & DERIVATION

T-tubules couple electrical surface depolarization of the sarcolemma with intracellular calcium release from terminal cisternae.

Formula / Rule / Reaction:

Action Potential $\xrightarrow{\text{T-tubules}}$ DHP Receptors $\xrightarrow{\text{Ryanodine Receptors}}$ Ca^{2+} Release from SR

Solution:

- Transverse tubules (T-tubules) are deep invaginations of the sarcolemma that run perpendicularly across the muscle fiber at the A-I band junctions.
- They form triads with adjacent terminal cisternae of the sarcoplasmic reticulum, rapidly carrying action potentials into the interior of the fiber.

Why other options are incorrect:

- **Option A:** Troponin is a regulatory globular protein complex attached to actin filaments, not a membrane tubular system.
- **Option C:** Myofibrils are longitudinal contractile protein bundles made of repeating sarcomeres inside the sarcoplasm.
- **Option D:** Sarcoplasmic tubules refers loosely to the longitudinal sarcoplasmic reticulum, which runs parallel rather than invaginating perpendicularly from the sarcolemma.

Question #64 Key: (B)BIOLOGY
03. Enzymes

The active site of an enzyme is defined as the specific catalytic region that:

CORE CONCEPT & DERIVATION

The active site is a three-dimensional cleft in a globular enzyme formed by catalytic and binding amino acid residues.

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

- The active site consists of a substrate-binding site (which provides geometric and chemical complementarity) and a catalytic site (which stabilizes the transition state and lowers activation energy).
- It directly engages substrate molecules to catalyze their transformation into products.

Why other options are incorrect:

- **Option A:** The active site releases reaction products because products exhibit low binding affinity for the site compared to the substrate.
- **Option C:** Allosteric regulators bind to regulatory sites located physically distant from the active site.
- **Option D:** While thermal denaturation alters the active site, this is a property of heat-induced unfolding rather than its functional biological definition.

Question #65 Key: (C)BIOLOGY
10. Homeostasis

Frostbite injuries resulting from extreme cold exposure are primarily caused by severe, prolonged...

CORE CONCEPT & DERIVATION

Exposure to extreme cold triggers sympathetic vasoconstriction to preserve core body heat, leading to peripheral ischemia and tissue freezing.

Formula / Rule / Reaction:

Severe Cold $\Rightarrow$ Sympathetic Peripheral Vasoconstriction $\Rightarrow$ Local Ischemia + Ice Crystal Formation

Solution:

- When exposed to subfreezing temperatures, the hypothalamus stimulates peripheral vasoconstriction to shunt blood away from extremities toward vital thoracic and abdominal organs.
- Prolonged cutaneous vasoconstriction severely restricts blood flow to fingers, toes, and ears, leading to hypoxia, ice crystal formation in interstitial fluid, and tissue necrosis known as frostbite.

Why other options are incorrect:

- Option A:** Fluid retention is not the causative vascular mechanism underlying localized cold injury.
- Option B:** Cutaneous vasodilation increases peripheral blood flow and heat loss, which is the physiological response to heat stress rather than freezing cold.
- Option D:** Muscular hypertrophy is the enlargement of muscle tissue due to exercise and has no bearing on acute thermal frostbite.

Question #67 Key: (A)BIOLOGY
09. Respiration / Gaseous Exchange

Which quaternary globular iron-containing protein transports oxygen from the respiratory surface...

CORE CONCEPT & DERIVATION

Systemic transport of molecular oxygen relies on cooperative binding to iron atoms within circulating erythrocytes.

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

- Hemoglobin is packed within red blood cells at high concentrations (approximately 15 g/dL of whole blood).
- It binds oxygen cooperatively in the pulmonary capillaries where partial pressure of oxygen is high, and releases oxygen in systemic capillary beds where oxygen partial pressure is low.

Why other options are incorrect:

- Option B:** Myoglobin is a monomeric intracellular oxygen-storage protein localized inside skeletal and cardiac muscle sarcoplasm, not in circulating blood.
- Option C:** Serum albumin is the most abundant plasma protein, responsible for maintaining oncotic pressure and transporting fatty acids and drugs.
- Option D:** Transferrin is a blood plasma glycoprotein that transports ferric iron (Fe^{3+}) between sites of absorption, storage, and utilization.

Question #66 Key: (B)BIOLOGY
13. Chemical Coordination

In which region of the brain are neurosecretory cells located that regulate the secretions of t...

CORE CONCEPT & DERIVATION

The hypothalamus integrates the nervous and endocrine systems via the hypothalamic-hypophyseal portal blood circulation.

Formula / Rule / Reaction:

Hypothalamic Neurosecretory Cells $\xrightarrow{\text{Releasing/Inhibiting Hormones}}$ Portal System $\rightarrow$ Anterior Pituitary

Solution:

- Peptidergic neurosecretory neurons in the hypothalamus (such as the arcuate, paraventricular, and preoptic nuclei) synthesize releasing hormones (e.g., TRH, CRH, GnRH, GHRH) and inhibiting hormones (e.g., somatostatin, dopamine).
- These hormones are released into the primary capillary plexus of the median eminence and travel through hypophyseal portal vessels to regulate anterior pituitary endocrine cells.

Why other options are incorrect:

- Option A:** The pons is a brainstem structure that relays sensory and motor signals and regulates respiratory rhythm.
- Option C:** The hippocampus is a limbic structure dedicated to memory consolidation and spatial mapping.
- Option D:** The amygdala processes emotions and emotional memories, without secreting releasing hormones into the portal system.

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

A rare condition of color blindness where an individual lacks functional blue cone photoreceptors...

CORE CONCEPT & DERIVATION

Color vision is trichromatic; congenital loss of short-wavelength (S-cone) photopigments causes blue-yellow dichromatic vision.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Tritanopia is an autosomal condition characterized by the absence of functional blue-sensitive (short-wavelength, ~420 nm) opsin photopigments in retinal cone cells.
- Affected individuals confuse blue with green and yellow with violet.

Why other options are incorrect:

- Option A:** Protanopia is red color blindness caused by the absence of red-sensitive (L-cone, long-wavelength) photoreceptors.
- Option B:** Deuteranopia is green color blindness caused by the absence of green-sensitive (M-cone, medium-wavelength) photoreceptors.
- Option D:** Monochromacy (achromatopsia) is complete total color blindness where only a single cone type or only rods function, resulting in vision in shades of gray.

Question #69 Key: (C)

CHEMISTRY
12. Transition Elements

The term "chelate" is derived from a Greek word meaning:

CORE CONCEPT & DERIVATION

Chelation describes coordination compounds in which a polydentate ligand binds a single central metal ion through multiple donor atoms.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The word "chelate" is derived from the Greek noun $\chi\eta\lambda\eta$ (chele), meaning "claw" or "crab's claw".
- This term was coined by Morgan and Drew in 1920 to describe the pincer-like attachment of two or more coordinating donor groups from a single ligand to a central metal ion.

Why other options are incorrect:

- Option A:** Bidentate describes a ligand possessing two donor atoms, which is a structural property rather than the etymology of the word chelate.
- Option B:** While chelates form stable cyclic coordination rings, the Greek root specifically translates to claw, not ring.
- Option D:** Complex refers to any coordination compound formed by a Lewis acid and Lewis bases.

Question #70 Key: (C)

CHEMISTRY
03. Chemical Bonding

According to VSEPR theory, the molecular geometry of an ammonia ([Formula]) molecule is:

CORE CONCEPT & DERIVATION

Valence Shell Electron Pair Repulsion (VSEPR) theory dictates that molecular geometry is determined by minimizing repulsions among bonding and lone electron pairs.

Formula / Rule / Reaction:

$$\text{Steric Number} = 3 (\text{bond pairs}) + 1 (\text{lone pair}) = 4 \Rightarrow \text{AX}_3\text{E}$$

Solution:

- The central nitrogen atom has 5 valence electrons, forming three single sigma bonds with hydrogen atoms while retaining one non-bonding lone pair.
- The four electron domains adopt a tetrahedral electron-pair geometry. Because of strong lone pair-bond pair repulsions, the bond angles compress to approximately 107.5° , resulting in a trigonal pyramidal molecular geometry.

Why other options are incorrect:

- Option A:** Tetrahedral is the electron-domain geometry, not the observed molecular geometry (which excludes non-bonding pairs).
- Option B:** Trigonal planar is the molecular geometry of AX_3 systems lacking lone pairs, such as BF_3 .
- Option D:** Bent (angular) is the molecular geometry of AX_2E or AX_3E_2 systems, such as H_2O .

Question #71 Key: (C)

CHEMISTRY
18. Carboxylic Acids

Which carboxylic acid is used as a preservative and antibacterial agent in livestock feed and g...

CORE CONCEPT & DERIVATION

Short-chain aliphatic carboxylic acids and their salts act as potent antifungal and antimicrobial food and feed preservatives.

Formula / Rule / Reaction:



Solution:

- Propionic acid (propanoic acid) and calcium propionate are widely applied to animal feed and stored agricultural grains.
- They inhibit the growth of molds, yeasts, and pathogenic bacteria by penetrating microbial membranes and lowering intracellular pH. Note: Formic acid has some industrial antimicrobial applications, but propionic acid is the standard textbook preservative in animal feed.

Why other options are incorrect:

- Option A:** Butyric acid has an unpleasant, rancid odor and is not used as a grain or feed preservative.
- Option B:** Formic acid is used mainly in leather tanning and silage preservation, not as the standard feed grain antimicrobial.
- Option D:** Valeric acid is a five-carbon carboxylic acid with a foul odor, unsuitable for use as a livestock feed additive.

Question #72 Key: (A)

CHEMISTRY
02. Atomic Structure

The magnitude of the elementary charge of an electron is:

CORE CONCEPT & DERIVATION

The elementary charge (e) is a fundamental physical constant representing the magnitude of electric charge carried by a single proton or electron.

Formula / Rule / Reaction:

$$e = 1.602176634 \times 10^{-19} \text{ C}$$

Solution:

- First determined precisely by Robert Millikan in his 1909 oil drop experiment, the standard SI value of elementary charge is 1.602×10^{-19} Coulombs.
- An electron carries a negative charge of $-1.602 \times 10^{-19} \text{ C}$.

Why other options are incorrect:

- Option B:** 10^{-16} C is three orders of magnitude larger than the elementary charge.
- Option C:** 10^{-18} C is one order of magnitude larger than the elementary charge.
- Option D:** 10^{-21} C is two orders of magnitude smaller than the elementary charge.

Question #73 Key: (B)CHEMISTRY
07. Equilibrium

The position of chemical equilibrium in which of the following gaseous reactions will not be af...

CORE CONCEPT & DERIVATION

According to Le Chatelier's principle, pressure changes alter equilibrium position only when there is a net change in the number of gaseous moles ($\Delta n_g \neq 0$).

Formula / Rule / Reaction:

$$\Delta n_g = \sum n_{\text{gaseous products}} - \sum n_{\text{gaseous reactants}} = 0 \implies \text{No Pressure Effect}$$

Solution:

- For the reaction $\text{N}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{NO}(g)$:
- Reactant moles = $1 + 1 = 2$; Product moles = 2.
- Since $\Delta n_g = 2 - 2 = 0$, a change in external pressure changes both sides equally, exerting no net shift in equilibrium position.

Why other options are incorrect:

- Option A:** $\Delta n_g = 2 - 3 = -1$; increasing pressure shifts equilibrium toward products.
- Option C:** $\Delta n_g = 2 - 3 = -1$; increasing pressure shifts equilibrium toward products.
- Option D:** $\Delta n_g = 2 - 1 = +1$; increasing pressure shifts equilibrium toward reactants.

Question #74 Key: (B)CHEMISTRY
05. Liquids

The density of liquid benzene ([Formula]) at room temperature is approximately:

CORE CONCEPT & DERIVATION

Benzene is a nonpolar aromatic hydrocarbon liquid that is less dense than water and immiscible with it.

Formula / Rule / Reaction:

$$\rho = \frac{\text{Mass}}{\text{Volume}} \approx 0.8765 \text{ g/cm}^3 \quad (\text{At } 20^\circ\text{C})$$

Solution:

- The experimental density of pure benzene at standard room temperature (20°C to 25°C) is 0.879 g/cm^3 .
- This rounds to 0.88 g/cm^3 in textbook tables, which explains why benzene floats on water.

Why other options are incorrect:

- Option A:** 0.80 g/cm^3 is typical of aliphatic straight-chain hydrocarbons such as kerosene or cyclohexane, but too low for benzene.
- Option C:** 0.95 g/cm^3 is typical of castor oil or dense halogenated organics.
- Option D:** 1.00 g/cm^3 is the standard density of liquid water at 4°C .

Question #75 Key: (A)CHEMISTRY
07. Equilibrium

According to Raoult's law for non-volatile, non-electrolyte solutes, the relative lowering of v...

CORE CONCEPT & DERIVATION

Adding a non-volatile solute reduces the fraction of solvent molecules at the liquid surface, decreasing the equilibrium vapor pressure.

Formula / Rule / Reaction:

$$\frac{\Delta P}{P^0} = \frac{P^0 - P}{P^0} = X_2$$

Solution:

- Raoult's law states that the relative lowering of vapor pressure ($\frac{\Delta P}{P^0}$) of a dilute solution containing a non-volatile, non-electrolyte solute is equal to the mole fraction of the solute (X_2).
- This colligative property depends entirely on the ratio of solute particles to total particles in solution.

Why other options are incorrect:

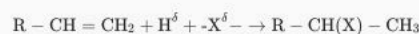
- Option B:** The vapor pressure of the solution itself (P) is directly proportional to the mole fraction of the solvent ($P = P^0 X_1$), not the relative lowering.
- Option C:** Molarity measures moles of solute per liter of solution and is temperature-dependent.
- Option D:** Molality is proportional to boiling point elevation and freezing point depression, but not equal to the relative lowering of vapor pressure.

Question #76 Key: (B)CHEMISTRY
14. Hydrocarbons

According to Markovnikov's rule, when an unsymmetrical reagent adds to an unsymmetrical alkene,...

CORE CONCEPT & DERIVATION

Electrophilic addition to unsymmetrical alkenes proceeds via the formation of the more stable carbocation intermediate.

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

- Markovnikov's rule states that the electrophile (positive part, usually H^+) attaches to the double-bonded carbon with more hydrogen atoms to generate a more substituted, stable carbocation.
- The nucleophile (negative part, X^-) then attacks the carbocation, bonding to the carbon bearing the fewer hydrogen atoms.

Why other options are incorrect:

- Option A:** The positive part of the adding reagent (hydrogen) adds to the carbon with the greater number of hydrogens.
- Option C:** Halogen content does not govern Markovnikov addition to simple alkenes.
- Option D:** If double-bonded carbons have equal numbers of hydrogens, addition lacks regioselectivity and yields isomeric mixtures.

Question #77 Key: (B)CHEMISTRY
04. Gases

According to Charles's law, at absolute zero ([Formula] or [Formula]), the volume of an ideal...

CORE CONCEPT & DERIVATION

Charles's law states that at constant pressure, the volume of a given mass of gas is directly proportional to its absolute temperature.

Formula / Rule / Reaction:

$$V_t = V_0 \left(1 + \frac{t}{273.15}\right) \Rightarrow V \propto T \quad (\text{At constant } P)$$

Solution:

- Extrapolating the linear volume-temperature isobar to $T = 0 \text{ K}$ (-273.15°C) causes the theoretical volume of an ideal gas to reach zero.
- In practice, real gases liquefy and solidify before reaching this temperature.

Why other options are incorrect:

- Option A:** Volume approaches zero, not infinity, as temperature approaches absolute zero.
- Option C:** 22.414 dm^3 is the molar volume of an ideal gas at standard temperature and pressure (0°C and 1 atm).
- Option D:** Volume is a physical scalar quantity that cannot possess negative values.

Question #78 Key: (B)CHEMISTRY
03. Chemical Bonding

The paramagnetic behavior of diatomic oxygen ([Formula]) molecules cannot be explained by:

CORE CONCEPT & DERIVATION

Paramagnetism requires unpaired electrons; theories that pair all valence electrons fail to account for magnetic susceptibility.

Formula / Rule / Reaction:

$$\text{MOT configuration of } \text{O}_2 : \dots (\pi_{2p_y}^*)^1 (\pi_{2p_z}^*)^1 \Rightarrow 2 \text{ Unpaired Electrons}$$

Solution:

- Valence Bond Theory (VBT) depicts the double bond in O_2 as one sigma and one pi bond formed by electron pairing, predicting a diamagnetic molecule with zero unpaired electrons.
- Molecular Orbital Theory (MOT) correctly places two degenerate electrons with parallel spins into antibonding π^* orbitals, explaining its experimentally observed paramagnetism.

Why other options are incorrect:

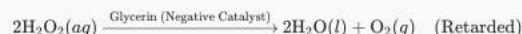
- Option A:** Molecular Orbital Theory explains and predicts the paramagnetism of O_2 .
- Option C:** Band Theory is used to describe electronic structure in continuous metallic conductors and semiconductors.
- Option D:** Crystal Field Theory applies to d-orbital splitting in transition metal coordination complexes.

Question #79 Key: (B)CHEMISTRY
09. Thermochemistry

The spontaneous decomposition of aqueous hydrogen peroxide ([Formula]) is inhibited by the ad...

CORE CONCEPT & DERIVATION

Negative catalysts (inhibitors) retard chemical reaction rates by binding catalytic traces or increasing activation energy.

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

- Aqueous H_2O_2 decomposes slowly into water and oxygen, a reaction catalyzed by trace heavy metals, dust, or alkali from glass.
- Adding small amounts of glycerin (glycerol), acetanilide, or dilute phosphoric acid acts as a stabilizer/negative catalyst, slowing down decomposition.

Why other options are incorrect:

- Option A:** MnO_2 is a strong positive catalyst that causes vigorous, rapid decomposition of H_2O_2 .
- Option C:** Finely divided platinum acts as a strong positive catalyst for H_2O_2 breakdown.
- Option D:** V_2O_5 is a positive catalyst used in oxidation reactions, such as the Contact process.

Question #80 Key: (C)CHEMISTRY
14. Hydrocarbons

The carbon-carbon ([Formula]) bond length in a benzene ring is intermediate between single an...

CORE CONCEPT & DERIVATION

Resonance delocalization of pi electrons in aromatic rings produces uniform carbon-carbon bond lengths intermediate between single and double bonds.

Formula / Rule / Reaction:

$$\text{C} - \text{C} (\text{Alkane}) = 1.54 \text{ \AA}, \quad \text{C} = \text{C} (\text{Alkene}) = 1.34 \text{ \AA}, \quad \text{C} \cdots \text{C} (\text{Benzene}) = 1.39 \text{ \AA}$$

Solution:

- X-ray diffraction confirms that all six carbon-carbon bonds in benzene are identical in length.
- Due to complete resonance delocalization of the 6 pi electrons over the ring, the bond length is $1.397 \text{ \AA}$ (approximately $1.39 \text{ \AA}$ or 0.139 nm), intermediate between an $sp^3 - sp^3$ single bond and an $sp^2 - sp^2$ double bond.

Why other options are incorrect:

- Option A:** $1.20 \text{ \AA}$ corresponds to a short carbon-carbon triple bond ($\text{C} \equiv \text{C}$) in alkynes.
- Option B:** $1.34 \text{ \AA}$ corresponds to a localized carbon-carbon double bond ($\text{C} = \text{C}$) in alkenes.
- Option D:** $1.54 \text{ \AA}$ corresponds to a localized carbon-carbon single bond ($\text{C} - \text{C}$) in alkanes.

Question #81 Key: (C)

CHEMISTRY
02. Atomic Structure

"No two electrons in the same atom can have an identical set of all four quantum numbers." This...

CORE CONCEPT & DERIVATION

The electronic configuration of atoms is restricted by quantum mechanical antisymmetry requirements for half-integer spin fermions.

Formula / Rule / Reaction:

For two electrons in the same orbital: $n_1 = n_2$, $l_1 = l_2$, $m_{l1} = m_{l2} \Rightarrow m_{s1} \neq m_{s2}$ ($+\frac{1}{2}, -\frac{1}{2}$)

Solution:

- Wolfgang Pauli formulated this exclusion principle in 1925.
- It states that an individual atomic orbital can hold a maximum of two electrons, and they must possess opposite spin states.

Why other options are incorrect:

- **Option A:** Hund's rule states that degenerate orbitals must be occupied singly with parallel spins before pairing occurs.
- **Option B:** The Aufbau principle dictates that electrons fill orbitals in order of increasing energy levels (the $n + l$ rule).
- **Option D:** Heisenberg's uncertainty principle states that it is impossible to simultaneously measure the exact position and momentum of a subatomic particle.

Question #82 Key: (B)

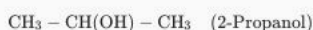
CHEMISTRY
17. Aldehydes & Ketones

The systematic IUPAC name of isopropyl alcohol is:

CORE CONCEPT & DERIVATION

IUPAC rules require numbering the longest continuous carbon chain to give the principal hydroxyl functional group the lowest locant.

Formula / Rule / Reaction:



Solution:

- The longest continuous carbon chain contains three carbon atoms (propane).
- The hydroxyl group ($-\text{OH}$) is attached to carbon-2. Adding the suffix "-ol" gives the systematic IUPAC name 2-propanol (or propan-2-ol).

Why other options are incorrect:

- **Option A:** 1-Propanol is the straight-chain primary alcohol isomer (n-propyl alcohol), $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$.
- **Option C:** 2-Butanol is a four-carbon secondary alcohol, $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$.
- **Option D:** 2-Methyl-2-propanol is a tertiary four-carbon alcohol (tert-butyl alcohol).

Question #83 Key: (C)

CHEMISTRY
08. Reaction Kinetics

The SI unit of the specific rate constant ([Formula]) for a first-order chemical reaction is:

CORE CONCEPT & DERIVATION

The dimensional units of the rate constant depend on the overall reaction order n .

Formula / Rule / Reaction:

$$\text{Units of } k = (\text{mol} \cdot \text{dm}^{-3})^{1-n} \cdot \text{s}^{-1}$$

Solution:

- For a first-order reaction ($n = 1$):
- Units of $k = (\text{mol} \cdot \text{dm}^{-3})^{1-1} \cdot \text{s}^{-1} = (\text{mol} \cdot \text{dm}^{-3})^0 \cdot \text{s}^{-1} = \text{s}^{-1}$.
- Therefore, the rate constant of a first-order reaction is independent of concentration and expressed in units of reciprocal time.

Why other options are incorrect:

- **Option A:** $\text{mol} \cdot \text{dm}^{-3} \cdot \text{s}^{-1}$ is the unit of rate constant for a zero-order reaction (and of reaction rate).
- **Option B:** $\text{dm}^3 \cdot \text{mol}^{-1} \cdot \text{s}^{-1}$ is the unit of rate constant for a second-order reaction.
- **Option D:** $\text{dm}^6 \cdot \text{mol}^{-2} \cdot \text{s}^{-1}$ is the unit of rate constant for a third-order reaction.

Question #84 Key: (B)

CHEMISTRY
09. Thermochemistry

In thermodynamics, volume ([Formula]) is classified as an extensive property and a:

CORE CONCEPT & DERIVATION

A state function is a thermodynamic property whose value depends solely on the current equilibrium state of the system, independent of the path taken.

Formula / Rule / Reaction:

$$\oint dV = 0 \Rightarrow \Delta V = V_2 - V_1$$

Solution:

- Because volume is uniquely fixed by temperature, pressure, and amount of substance, its change (ΔV) during a thermodynamic process depends only on the initial and final states.
- This makes volume a state function.

Why other options are incorrect:

- **Option A:** Path functions (e.g., heat q and work w) depend directly on the specific intermediate pathway taken during a transformation.
- **Option C:** A work function is a surface photoelectric property or a specific thermodynamic potential (Helmholtz free energy).
- **Option D:** Non-equilibrium functions are transient variables describing irreversible dissipative flows.

Question #85 Key: (C)CHEMISTRY
04. Gases

The calculation of the partial pressure of a dry gas collected over water by subtracting the aq...

CORE CONCEPT & DERIVATION

The total pressure exerted by a mixture of non-reacting gases is the sum of their individual partial pressures.

Formula / Rule / Reaction:

$$P_{\text{total}} = P_{\text{dry gas}} + P_{\text{water vapor}} \implies P_{\text{dry gas}} = P_{\text{total}} - \text{Aqueous Tension}$$

Solution:

- Gases collected over water become saturated with water vapor.
- According to Dalton's law of partial pressures, the total pressure is the sum of the partial pressure of the dry gas and the vapor pressure of water (aqueous tension) at that temperature. Subtracting the aqueous tension yields the true pressure of the dry gas.

Why other options are incorrect:

- Option A:** Boyle's law describes the inverse relationship between the pressure and volume of a fixed mass of gas at constant temperature.
- Option B:** Graham's law states that rates of effusion of gases are inversely proportional to the square roots of their molar masses.
- Option D:** Avogadro's law states that equal volumes of all gases under identical conditions contain equal numbers of molecules.

Question #86 Key: (C)CHEMISTRY
06. Solids

Dry ice (solid carbon dioxide, [Formula]) is a classic example of a:

CORE CONCEPT & DERIVATION

Molecular solids consist of discrete covalent molecules held together in a crystalline lattice by intermolecular van der Waals forces.

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

- In solid carbon dioxide, individual nonpolar linear $\text{O}=\text{C}=\text{O}$ molecules occupy fixed lattice points.
- These molecules are held together by weak London dispersion forces, causing dry ice to sublime directly into gas at -78.5°C at atmospheric pressure.

Why other options are incorrect:

- Option A:** Ionic solids (e.g., NaCl) consist of alternating cations and anions held by strong electrostatic forces.
- Option B:** Covalent network solids (e.g., diamond, quartz) consist of continuous arrays of covalent bonds throughout the crystal.
- Option D:** Metallic solids consist of metal cations held within a delocalized sea of valence electrons.

Question #87 Key: (A)CHEMISTRY
04. Gases

In meteorological and atmospheric science, a regional low-pressure system is referred to as a:

CORE CONCEPT & DERIVATION

Atmospheric pressure gradients govern weather systems, where converging air columns create regions of low barometric pressure.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In physical chemistry and meteorology, an atmospheric depression refers to a weather region where the barometric pressure is lower than that of the surrounding air.
- Depressions lead to rising air masses, cloud formation, and precipitation.

Why other options are incorrect:

- Option B:** An anticyclone is a high-pressure weather system characterized by descending air, clear skies, and calm conditions.
- Option C:** Diffusion is the passive net movement of particles from regions of higher concentration to lower concentration.
- Option D:** Compression zone refers to a mechanical area undergoing inward compressive stress.

Question #88 Key: (B)CHEMISTRY
07. Equilibrium

The normal physiological pH range of healthy human arterial blood is tightly regulated at appro...

CORE CONCEPT & DERIVATION

Human blood pH is maintained in a narrow alkaline range by physiological buffer systems, primarily the bicarbonate buffer.

Formula / Rule / Reaction:

$$\text{pH} = \text{p}K_a + \log\left(\frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}\right) = 6.1 + \log(20) = 7.40$$

Solution:

- The physiological pH of human systemic arterial blood is strictly buffered between 7.35 and 7.45 (mean 7.40).
- A blood pH below 7.35 represents acidemia, whereas a pH above 7.45 represents alkalemia.

Why other options are incorrect:

- Option A:** A pH of 6.80 to 7.00 is severe acidemia and incompatible with human life.
- Option C:** A pH of 7.80 to 8.00 represents severe alkalemia, which disrupts enzyme function and leads to fatal tetany.
- Option D:** A pH of 7.05 to 7.15 represents severe diabetic or lactic acidosis.

Question #89 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones

Which diagnostic chemical reagent, consisting of anhydrous zinc chloride in concentrated hydrochloric acid, is used to distinguish between primary, secondary, and tertiary alcohols?

CORE CONCEPT & DERIVATION

The Lucas test differentiates alcohols based on the relative stability of the carbocation intermediate formed during reaction with hydrogen halides.

Formula / Rule / Reaction:



Solution:

- Lucas reagent is an equimolar solution of anhydrous $ZnCl_2$ in concentrated HCl .
- Tertiary alcohols react immediately to form an insoluble, cloudy layer of alkyl chloride. Secondary alcohols produce turbidity within 5 to 10 minutes, while primary alcohols do not produce turbidity at room temperature unless heated.

Why other options are incorrect:

- Option A:** Tollens' reagent (ammoniacal silver nitrate) is used to distinguish aldehydes from ketones by forming a silver mirror.
- Option C:** Benedict's reagent is used to detect reducing sugars.
- Option D:** Fehling's solution is an alkaline copper tartrate complex used to detect aliphatic aldehydes and reducing sugars.

Question #90 Key: (A)

CHEMISTRY
09. Thermochemistry

Which of the following biochemical processes is an endothermic reaction?

CORE CONCEPT & DERIVATION

Endothermic processes absorb thermal or radiant energy from their surroundings to form higher-energy chemical bonds ($\Delta H > 0$).

Formula / Rule / Reaction:



Solution:

- Photosynthesis captures solar photon energy to drive the endergonic reduction of carbon dioxide into glucose.
- Because energy is continuously absorbed, the enthalpy change is positive ($\Delta H > 0$), making it an endothermic process.

Why other options are incorrect:

- Option B:** Cellular respiration oxidizes glucose to release approximately 2800 kJ/mol of energy ($\Delta H < 0$), making it exothermic.
- Option C:** Combustion of fuels and carbohydrates releases heat and light, making it strongly exothermic.
- Option D:** Neutralization between strong acids and bases releases approximately 57.3 kJ/mol of heat, making it an exothermic reaction.

Question #91 Key: (B)

CHEMISTRY
01. Stoichiometry

Stoichiometry is defined as the branch of chemistry that studies the ___ relationships between ___.

CORE CONCEPT & DERIVATION

Stoichiometry applies the law of conservation of mass to relate the mole, mass, and volume proportions of reacting substances.

Formula / Rule / Reaction:



Solution:

- Stoichiometry deals with calculating the numerical, quantitative amounts of reactants consumed and products formed in a balanced reaction.
- It relies on fixed stoichiometric mole ratios between species.

Why other options are incorrect:

- Option A:** Qualitative analysis identifies chemical identity and composition, not numerical mass relationships.
- Option C:** Empirical refers to experimental observations or the simplest whole-number atomic ratio in a formula.
- Option D:** Chemical kinetics studies the rates and molecular mechanisms of chemical reactions over time.

Question #92 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones

When aliphatic ketones are reduced using lithium aluminum hydride ($[LiAlH_4]$), they yield:

CORE CONCEPT & DERIVATION

Complex metal hydrides reduce carbonyl groups by delivering nucleophilic hydride ions to the electrophilic carbonyl carbon.

Formula / Rule / Reaction:



Solution:

- In a ketone, the carbonyl carbon is bonded to two alkyl groups.
- Nucleophilic attack by a hydride ion (H^-) followed by protonation converts the carbonyl group into a secondary alcohol functional group ($-CH(OH)-$).

Why other options are incorrect:

- Option A:** Reduction of aldehydes, esters, and acyl chlorides yields primary alcohols.
- Option C:** Tertiary alcohols are synthesized by the addition of Grignard reagents to ketones, not by reduction of ketones.
- Option D:** Carboxylic acids represent an oxidized state; ketones do not oxidize to acids under reducing conditions.

Question #93 Key: (B)CHEMISTRY
07. Equilibrium

In the Law of Mass Action, the term "active mass" is mathematically defined as the molar concentration...

CORE CONCEPT & DERIVATION

Guldberg and Waage's Law of Mass Action states that chemical reaction rates are directly proportional to the product of the active masses of reactants.

Formula / Rule / Reaction:

$$\text{Active Mass} = [A] = \frac{n}{V} = \frac{\text{Moles}}{\text{dm}^3} \quad (\text{mol} \cdot \text{dm}^{-3})$$

Solution:

- "Active mass" is the effective concentration of a reacting substance participating in a chemical system.
- In homogeneous solution reactions, active mass is represented in square brackets and measured as molarity in moles per cubic decimeter (mol/dm^3).

Why other options are incorrect:

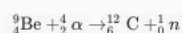
- **Option A:** g/dm^3 is mass concentration, not molar active mass.
- **Option C:** mol/dm^2 is an areal concentration unit used in surface science, not volumetric active mass.
- **Option D:** g/mol is the unit of molar mass.

Question #94 Key: (C)CHEMISTRY
02. Atomic Structure

The subatomic neutral particle, the neutron, was discovered in 1932 by:

CORE CONCEPT & DERIVATION

The discovery of the uncharged nucleon resolved discrepancies between atomic number and atomic mass in the nuclear model.

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

- In 1932, James Chadwick bombarded a thin target of beryllium with alpha particles emitted from polonium.
- He detected penetrating, electrically neutral radiation that ejected protons from paraffin wax. Determining that this radiation consisted of neutral particles of mass roughly equal to protons, he named them neutrons.

Why other options are incorrect:

- **Option A:** J.J. Thomson discovered the electron in 1897 using cathode-ray tube experiments.
- **Option B:** Ernest Rutherford discovered the atomic nucleus in 1911 and the proton in 1919.
- **Option D:** Niels Bohr formulated the quantized orbital model of the hydrogen atom in 1913.

Question #95 Key: (B)CHEMISTRY
14. Hydrocarbons

In the industrial Dow process, when chlorobenzene reacts with aqueous sodium hydroxide at [Form...]

CORE CONCEPT & DERIVATION

Nucleophilic aromatic substitution of unactivated aryl halides requires harsh conditions and yields a phenoxide salt in basic solution.

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

- Because the chlorine atom in chlorobenzene is stabilized by resonance donation into the benzene ring, direct displacement requires high temperature (350°C) and pressure (150 atm).
- In strong base, the reaction yields sodium phenoxide ($\text{C}_6\text{H}_5\text{ONa}$). Free phenol is liberated only after subsequent acidification with HCl.

Why other options are incorrect:

- **Option A:** Phenol is the final product obtained after acid hydrolysis of sodium phenoxide, not the immediate reaction product in strong base.
- **Option C:** Benzene is not formed during the nucleophilic substitution of chlorobenzene.
- **Option D:** Benzoic acid possesses a carboxyl group, which is not produced in this substitution reaction.

Question #96 Key: (D)CHEMISTRY
18. Carboxylic Acids

Aliphatic carboxylic acids are stronger Bronsted-Lowry acids than which of the following compounds...

CORE CONCEPT & DERIVATION

Carboxylic acids are weak organic acids, but they are significantly stronger than alcohols due to resonance stabilization of the carboxylate anion.

Formula / Rule / Reaction:

$$\text{p}K_a(\text{HCl}) \approx -7, \quad \text{p}K_a(\text{CH}_3\text{COOH}) \approx 4.76, \quad \text{p}K_a(\text{CH}_3\text{OH}) \approx 15.5$$

Solution:

- Methanol has a $\text{p}K_a$ of ~15.5, meaning it is a very weak acid.
- In contrast, carboxylic acids have $\text{p}K_a$ values around 4 to 5 because the negative charge on the conjugate base is delocalized equally over two electronegative oxygen atoms. Therefore, carboxylic acids are roughly 10^{10} times stronger acids than methanol.

Why other options are incorrect:

- **Option A:** Hydrochloric acid is a strong mineral acid ($\text{p}K_a \approx -7$), which is far stronger than carboxylic acids.
- **Option B:** Sulfuric acid is a strong diprotic mineral acid, much stronger than carboxylic acids.
- **Option C:** Nitric acid is a strong oxidizing mineral acid, significantly stronger than carboxylic acids.

Question #97 Key: (B)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

The major natural gas field in Pakistan was first discovered in the Sui area of Balochistan in ...

CORE CONCEPT & DERIVATION

Pakistan's primary indigenous fossil hydrocarbon reserves were discovered during mid-20th-century petroleum exploration.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The Sui gas field, located in the Dera Bugti district of Balochistan, was discovered in 1952 by Pakistan Petroleum Limited (PPL).
- Commercial transmission of natural gas from this reservoir began in 1955.

Why other options are incorrect:

- Option A:** 1947 is the year of Pakistan's independence, prior to the discovery at Sui.
- Option C:** 1956 is the year Pakistan adopted its first constitution.
- Option D:** 1965 corresponds to the second Indo-Pakistani war, over a decade after the Sui gas discovery.

Question #98 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones

The direct reduction of carbonyl groups in aldehydes and ketones to methylene ([Formula]) gro...

CORE CONCEPT & DERIVATION

Clemmensen reduction selectively converts aldehydes and ketones into corresponding alkanes under strongly acidic reducing conditions.

Formula / Rule / Reaction:



Solution:

- The Clemmensen reduction uses zinc amalgam in concentrated HCl to reduce carbonyl groups to methylene groups.
- This reaction is ideal for acid-stable aldehydes and ketones.

Why other options are incorrect:

- Option A:** Wolff-Kishner reduction converts carbonyls to alkanes using hydrazine (NH₂NH₂) and strong base (KOH) under alkaline conditions.
- Option C:** Rosenmund reduction converts acyl chlorides to aldehydes using hydrogen gas over poisoned palladium catalyst (Pd/BaSO₄).
- Option D:** Sabatier-Senderens reaction is the catalytic hydrogenation of alkenes or alkynes to alkanes using finely divided nickel.

Question #99 Key: (B)

CHEMISTRY
19. Macromolecules / Biochemistry

Dietary deficiency of which trace mineral element causes loss of appetite (anorexia), impaired ...

CORE CONCEPT & DERIVATION

Zinc is a cofactor for over 300 metalloenzymes, including gustin, carbonic anhydrase, and DNA/RNA polymerases.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Zinc is required by carbonic anhydrase VI (gustin), a salivary metalloenzyme responsible for the development and maintenance of taste buds.
- Deficiency leads directly to hypogeusia (blunted taste sensation), loss of appetite, alopecia, and impaired wound healing due to reduced collagen synthesis.

Why other options are incorrect:

- Option A:** Iron deficiency causes microcytic hypochromic anemia, fatigue, and pallor.
- Option C:** Potassium deficiency causes muscle weakness, cardiac arrhythmias, and hypokalemic paralysis.
- Option D:** Phosphorus deficiency causes osteomalacia, rickets, and impaired ATP synthesis.

Question #100 Key: (B)

CHEMISTRY
15. Alkyl Halides

The reaction rate of a unimolecular nucleophilic substitution ([Formula]) mechanism depends d...

CORE CONCEPT & DERIVATION

An S_N1 reaction proceeds via a two-step mechanism where the slow, rate-determining step involves only the ionization of the substrate.

Formula / Rule / Reaction:

$$\text{Rate} = k[\text{Substrate}]^1$$

Solution:

- In an S_N1 substitution (typical of tertiary alkyl halides), the leaving group departs in a slow, reversible unimolecular step to generate a carbocation intermediate.
- Because the nucleophile participates only in the fast subsequent step, the rate law is first order overall, depending solely on the concentration of the substrate.

Why other options are incorrect:

- Option A:** Nucleophile concentration does not affect the rate-determining formation of the carbocation in an S_N1 reaction.
- Option C:** Dependence on both substrate and nucleophile concentration characterizes a bimolecular S_N2 mechanism (Rate = k[Substrate][Nu⁻]).
- Option D:** The reaction occurs without an added external catalyst.

Question #101 Key: (C)

CHEMISTRY
19. Macromolecules / Biochemistry

The total number of alpha amino acids that participate in protein synthesis in biological systems...

CORE CONCEPT & DERIVATION

While 20 standard amino acids are encoded by the universal genetic code, two additional non-standard amino acids are co-translationally inserted into proteins.

Formula / Rule / Reaction:

$$\text{Total Proteogenic Amino Acids} = 20 (\text{Standard}) + 2 (\text{Selenocysteine, Pyrrolysine}) = 22$$

Solution:

- The standard genetic code specifies 20 universal alpha amino acids.
- In specialized biological systems, the 21st amino acid (selenocysteine, encoded by UGA) and the 22nd amino acid (pyrrolysine, encoded by UAG) are directly incorporated into polypeptide chains during translation, bringing the total count to 22.

Why other options are incorrect:

- Option A:** 19 does not represent the full set of universal standard amino acids.
- Option B:** 20 represents only the classical standard amino acids and omits the two recognized genetically encoded additions.
- Option D:** 25 exceeds the number of known proteogenic amino acids.

Question #102 Key: (C)

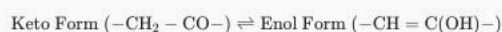
CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Which statement about tautomerism is correct?

CORE CONCEPT & DERIVATION

Tautomerism is a form of dynamic structural isomerism where isomers interconvert rapidly through the migration of a proton accompanied by a pi-bond shift.

Formula / Rule / Reaction:



Solution:

- Because tautomers are constitutional isomers, they share an identical molecular formula and molecular weight.
- They differ in the spatial connectivity of atoms and exist in dynamic chemical equilibrium.

Why other options are incorrect:

- Option A:** Tautomerism is widespread in organic compounds (e.g., keto-enol, nitro-acinitro, lactam-lactim).
- Option B:** The equilibrium position between tautomers depends directly on temperature, solvent polarity, and concentration.
- Option D:** Tautomers contain different functional groups and exhibit distinct physical constants and chemical reactivities.

Question #103 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones

Aldehydes and ketones can be reduced directly into alkanes using hydrazine in the presence of...

CORE CONCEPT & DERIVATION

The Wolff-Kishner reduction deoxygenates carbonyl groups into methylene units under strongly alkaline conditions at elevated temperatures.

Formula / Rule / Reaction:



Solution:

- The carbonyl compound reacts with hydrazine to form a hydrazone intermediate.
- Heating the hydrazone in the presence of a strong base (KOH) in a high-boiling solvent drives off nitrogen gas (N₂), yielding the corresponding alkane.

Why other options are incorrect:

- Option A:** The Lucas test uses anhydrous ZnCl₂ and concentrated HCl to classify alcohols.
- Option C:** The Grignard reaction involves nucleophilic organomagnesium halides adding to electrophilic carbons to form carbon-carbon bonds.
- Option D:** The Friedel-Crafts reaction involves electrophilic aromatic alkylation or acylation catalyzed by Lewis acids.

Question #104 Key: (C)

CHEMISTRY
12. Transition Elements

An example of a bidentate ligand among the following is:

CORE CONCEPT & DERIVATION

A bidentate ligand possesses two donor atoms that can coordinate simultaneously to a single central metal ion, forming a chelate ring.

Formula / Rule / Reaction:



Solution:

- The oxalate dianion (C₂O₄²⁻) contains two negatively charged carboxylate oxygen atoms.
- Each oxygen donates a lone pair of electrons to the metal center, forming a stable five-membered chelate ring.

Why other options are incorrect:

- Option A:** Bromide (Br⁻) is a monodentate ligand that donates only one electron pair to a metal ion.
- Option B:** Cyanide (CN⁻) is an ambidentate ligand that coordinates through either carbon or nitrogen, but only as a monodentate donor at any given time.
- Option D:** Hydroxide (OH⁻) is a monodentate ligand.

Question #105 Key: (C)

CHEMISTRY
10. Electrochemistry

A hydrogen fuel cell is an electrochemical galvanic cell that continuously converts chemical en...

CORE CONCEPT & DERIVATION

A fuel cell converts the chemical energy of a continuously supplied fuel and oxidant directly into electrical energy via redox reactions.

Formula / Rule / Reaction:



Solution:

- At the porous anode, hydrogen is oxidized: $2\text{H}_2 \rightarrow 4\text{H}^+ + 4\text{e}^-$.
- At the porous cathode, oxygen is reduced: $\text{O}_2 + 4\text{H}^+ + 4\text{e}^- \rightarrow 2\text{H}_2\text{O}$. Combining these gives water as the sole byproduct alongside an electrical potential of 1.23 V.

Why other options are incorrect:

- Option A:** Copper is a metal electrode conductor, not a gaseous redox reactant in a standard fuel cell.
- Option B:** Methane and oxygen are used in direct hydrocarbon fuel cells, not in standard hydrogen fuel cells.
- Option D:** Nitrogen and oxygen do not undergo spontaneous galvanic redox reactions under standard conditions.

Question #106 Key: (B)

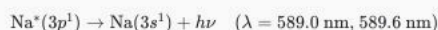
CHEMISTRY
11. S & P Block Elements

Which alkali metal produces a characteristic persistent golden-yellow coloration in a flame tes...

CORE CONCEPT & DERIVATION

Thermal excitation of outer s-electrons followed by radiative de-excitation produces characteristic atomic emission lines in the visible spectrum.

Formula / Rule / Reaction:



Solution:

- When sodium salts are introduced into a non-luminous Bunsen flame, outer electrons are promoted from the 3s to the 3p orbital.
- De-excitation back to the ground state emits bright double lines (the sodium D-lines at 589 nm), imparting a persistent golden-yellow color to the flame.

Why other options are incorrect:

- Option A:** Barium (an alkaline earth metal) imparts an apple-green color to the flame.
- Option C:** Potassium imparts a lilac (violet) color to the flame.
- Option D:** Cesium imparts a blue-violet color to the flame.

Question #107 Key: (D)

CHEMISTRY
05. Liquids

Which of the following monoatomic or diatomic species possesses the weakest London dispersion f...

CORE CONCEPT & DERIVATION

London dispersion forces depend directly on the polarizability of an electron cloud, which increases with atomic size and total electron count.

Formula / Rule / Reaction:

$$\text{Polarizability} \propto \text{Number of Electrons} \implies \text{Dispersion Force Strength}$$

Solution:

- Helium (He) possesses only 2 electrons tightly held in a compact 1s orbital close to the nucleus.
- Because of its minimal polarizability and tiny atomic radius, helium exhibits the weakest intermolecular London dispersion forces of any known substance.

Why other options are incorrect:

- Option A:** Fluorine (F_2) has 18 electrons and higher polarizability than helium.
- Option B:** Chlorine (Cl_2) has 34 electrons and exhibits moderate dispersion forces, existing as a gas at room temperature.
- Option C:** Bromine (Br_2) has 70 electrons and exhibits strong dispersion forces, existing as a liquid at room temperature.

Question #108 Key: (B)

CHEMISTRY
05. Liquids

Among the following pure liquids, which exhibits the highest surface tension at room temperatur...

CORE CONCEPT & DERIVATION

Surface tension arises from net inward cohesive forces acting on surface molecules, which are strongest in metallic liquids.

Formula / Rule / Reaction:

$$\gamma(\text{Hg}) \approx 486 \text{ mN/m} \gg \gamma(\text{H}_2\text{O}) \approx 72.8 \text{ mN/m} > \gamma(\text{Benzene}) \approx 28.9 \text{ mN/m}$$

Solution:

- Mercury is a liquid metal held together by cohesive metallic bonds between mercury cations and delocalized valence electrons.
- Its surface tension (approximately 486 mN/m) is nearly seven times greater than the surface tension of water (72.8 mN/m).

Why other options are incorrect:

- Option A:** Water has high surface tension among common molecular solvents due to hydrogen bonding, but it is far lower than that of liquid mercury.
- Option C:** Ethyl alcohol has weaker hydrogen bonding than water, with a surface tension of only ~22.3 mN/m.
- Option D:** Benzene is held only by weak London dispersion forces, with a surface tension of ~28.9 mN/m.

Question #109 Key: (C)

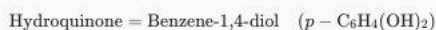
CHEMISTRY
16. Alcohols & Phenols

Hydroquinone (quinol) is a dihydroxybenzene derivative containing two hydroxyl ([Formula]) gr...

CORE CONCEPT & DERIVATION

Dihydroxybenzenes exist as three positional isomers: 1,2- (ortho), 1,3- (meta), and 1,4- (para).

Formula / Rule / Reaction:



Solution:

- Hydroquinone (1,4-dihydroxybenzene) has two hydroxyl groups situated para to each other across the benzene ring.
- This symmetrical arrangement allows it to undergo reversible oxidation to 1,4-benzoquinone.

Why other options are incorrect:

- Option A:** 1,2-Dihydroxybenzene is catechol (pyrocatechol).
- Option B:** 1,3-Dihydroxybenzene is resorcinol.
- Option D:** 2 and 3 is chemically identical to the 1,2-positioning found in catechol.

Question #110 Key: (A)

CHEMISTRY
01. Stoichiometry

In practical chemical synthesis, the actual yield obtained experimentally is generally:

CORE CONCEPT & DERIVATION

The theoretical yield is the maximum calculated product mass, which is rarely matched in laboratory practice due to chemical and physical losses.

Formula / Rule / Reaction:

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

Solution:

- Actual yields fall below theoretical predictions due to incomplete reactions, side reactions forming secondary byproducts, and reversible equilibria.
- Mechanical losses during filtration, washing, recrystallization, and transfer also reduce recovered product mass.

Why other options are incorrect:

- Option B:** An actual yield equal to the theoretical yield requires 100% reaction completion with zero experimental mass loss, which is not achieved in practical synthesis.
- Option C:** An actual yield greater than theoretical yield violates the law of conservation of mass (or indicates an unpurified, solvent-contaminated product).
- Option D:** Actual yield is quantitatively related to theoretical yield through the percent yield equation.

Question #111 Key: (B)

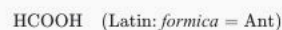
CHEMISTRY
18. Carboxylic Acids

Formic acid (methanoic acid, [Formula]) is naturally produced in the venom and defensive sting...

CORE CONCEPT & DERIVATION

Formic acid was historically isolated by distilling red ants, from which it derives its name.

Formula / Rule / Reaction:



Solution:

- Ants of the subfamily Formicinae synthesize and store concentrated formic acid in specialized venom glands.
- They spray or inject this acid through their stingers as a defensive chemical deterrent against predators.

Why other options are incorrect:

- Option A:** Honeybee venom (apitoxin) is a complex mixture of peptides (melittin, apamin) and enzymes, with only trace acid content.
- Option C:** Wasp venom is typically neutral or alkaline, containing histamine and kinin polypeptides.
- Option D:** Scorpion venom consists of neurotoxic polypeptide channel blockers.

Question #112 Key: (B)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Friedrich Wohler synthesized urea in 1828 by heating which inorganic precursor compound, thereb...

CORE CONCEPT & DERIVATION

Wohler's synthesis demonstrated that organic biological compounds can be synthesized from non-living inorganic minerals without a "vital force".

Formula / Rule / Reaction:



Solution:

- In 1828, Friedrich Wohler attempted to prepare ammonium cyanate by treating silver cyanate with ammonium chloride.
- Upon evaporating the aqueous solution, ammonium cyanate underwent thermal isomerization into urea, establishing the foundation of modern synthetic organic chemistry.

Why other options are incorrect:

- Option A:** Heating ammonium nitrate (NH_4NO_3) decomposes it into nitrous oxide (N_2O) and water.
- Option C:** Heating ammonium chloride (NH_4Cl) causes reversible dissociation into ammonia and hydrogen chloride gas.
- Option D:** Ammonium carbonate decomposes into ammonia, carbon dioxide, and water upon heating.

Question #113 Key: (C)

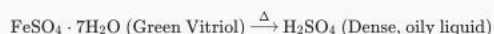
CHEMISTRY
11. S & P Block Elements

Historically, concentrated sulfuric acid ([Formula]) was referred to by alchemists and early ...

CORE CONCEPT & DERIVATION

Historical chemical nomenclature named concentrated mineral acids based on their alchemical mineral sources and physical properties.

Formula / Rule / Reaction:



Solution:

- Medieval alchemists prepared sulfuric acid by thermal roasting of hydrated iron(II) sulfate crystals, known as "green vitriol".
- Because the resulting acid was a dense, viscous liquid with an oily appearance, it was termed "oil of vitriol".

Why other options are incorrect:

- Option A:** Caustic soda is the traditional common name for sodium hydroxide (NaOH).
- Option B:** Aqua regia is a 3:1 volumetric mixture of concentrated hydrochloric acid and nitric acid capable of dissolving gold.
- Option D:** Muriatic acid is the historical common name for hydrochloric acid (HCl).

Question #114 Key: (B)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

A molecule of Buckminsterfullerene ([Formula], Buckyball) is constructed from how many five-m...

CORE CONCEPT & DERIVATION

The geometry of closed spherical fullerene cages follows Euler's polyhedral formula, requiring a fixed number of pentagons to generate curvature.

Formula / Rule / Reaction:

$$\text{Total Rings} = 32 \implies 12 \text{ Pentagons} + 20 \text{ Hexagons}$$

Solution:

- C_{60} adopts a truncated icosahedral structure matching the geometry of a classic soccer ball.
- It contains exactly 12 isolated pentagonal rings (each surrounded entirely by hexagons to eliminate pentagon-pentagon strain) and 20 hexagonal rings.

Why other options are incorrect:

- Option A:** Inverts the ring counts; a cage with 20 pentagons cannot form the C_{60} truncated icosahedron.
- Option C:** 14 and 14 is structurally incorrect for any stable closed fullerene.
- Option D:** 12 and 12 provides an insufficient number of hexagonal rings to close a 60-carbon cage.

Question #115 Key: (D)

CHEMISTRY
06. Solids

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

CORE CONCEPT & DERIVATION

Crystalline solids possess long-range, periodic, repeating geometric arrangements of constituent particles with sharp melting points.

Formula / Rule / Reaction:



Solution:

- Potash alum is an inorganic double salt that crystallizes into well-defined octahedral crystal lattices.
- It possesses sharp, distinct melting points and characteristic cleavage planes.

Why other options are incorrect:

- Option A:** Glass is a supercooled, amorphous inorganic silicate liquid lacking long-range repeating order.
- Option B:** Rubber is an amorphous elastomer made of tangled, non-crystalline polymer chains.
- Option C:** Plastics are synthetic organic polymers that are amorphous or only semi-crystalline, lacking true single-crystal lattices.

Question #116 Key: (B)

CHEMISTRY
03. Chemical Bonding

According to VSEPR theory, the molecular geometry around the nitrogen atom in primary aliphatic...

CORE CONCEPT & DERIVATION

The nitrogen atom in amines is sp^3 -hybridized, with three bonding pairs and one non-bonding lone pair shaping the geometry.

Formula / Rule / Reaction:

$$\text{Steric Number} = 3\sigma + 1 \text{ Lone Pair} = 4 \implies \text{Trigonal Pyramidal Geometry}$$

Solution:

- The nitrogen atom in a primary amine forms three single sigma bonds (one with carbon and two with hydrogen).
- The remaining lone pair occupies the fourth sp^3 hybrid orbital, compressing the bond angles to $\sim 107^\circ$ and producing a trigonal pyramidal molecular geometry.

Why other options are incorrect:

- Option A:** Trigonal planar geometry requires sp^2 hybridization with zero lone pairs (e.g., in carbocations or boron trifluoride).
- Option C:** Regular tetrahedral requires four identical bonding pairs with zero lone pairs (e.g., in CH_4 or NH_4^+).
- Option D:** Linear geometry requires two bonding domains with 180° bond angles.

Question #117 Key: (A)

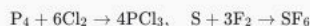
CHEMISTRY
11. S & P Block Elements

Most non-metallic p-block elements readily react directly with ___ to form binary covalent comp...

CORE CONCEPT & DERIVATION

Because of their high electronegativities, halogens readily share electrons with p-block non-metals to form covalent binary halides.

Formula / Rule / Reaction:



Solution:

- Non-metals of the p-block (such as carbon, nitrogen, phosphorus, sulfur, and oxygen) react directly with halogens (F_2 , Cl_2 , Br_2).
- They form stable, volatile binary molecular halides (e.g., CCl_4 , PCl_5 , SF_6) through covalent electron sharing.

Why other options are incorrect:

- Option B:** Noble gases have complete octets and are inert, reacting only under specialized conditions with fluorine.
- Option C:** Reactions with alkali metals form ionic binary salts rather than molecular p-block covalent compounds.
- Option D:** p-block non-metals do not react with transition metals exclusively.

Question #118 Key: (B)

CHEMISTRY
02. Atomic Structure

The maximum number of electrons that can be accommodated in a given atomic subshell defined by ...

CORE CONCEPT & DERIVATION

The number of degenerate orbitals in a subshell is $2l + 1$, and by the Pauli exclusion principle, each orbital holds up to 2 electrons.

Formula / Rule / Reaction:

$$\text{Max Electrons in Subshell} = 2(2l + 1) = 4l + 2$$

Solution:

- For a subshell with azimuthal quantum number l , the magnetic quantum number m_l takes $2l + 1$ values.
- Because each individual orbital can host a maximum of two electrons with antiparallel spins, the total capacity of the subshell is $2 \times (2l + 1) = 4l + 2$. Note: While some board keys confuse this with $2l + 1$ (the orbital count), $2(2l + 1)$ is the mathematically correct electron capacity.

Why other options are incorrect:

- Option A:** $2l + 1$ gives the total number of orbitals in a subshell, not the maximum number of electrons.
- Option C:** $2n^2$ gives the maximum number of electrons in an entire principal shell n .
- Option D:** n^2 gives the total number of orbitals in a principal shell n .

Question #119 Key: (C)

CHEMISTRY
03. Chemical Bonding

In VSEPR classification, a molecule designated as [Formula] with zero lone pairs on the central...

CORE CONCEPT & DERIVATION

Two bonding electron domains attached to a central atom minimize electrostatic repulsions when oriented on opposite sides at 180° .

Formula / Rule / Reaction:

$$\text{Steric Number} = 2 \implies \text{Bond Angle} = 180^\circ \implies \text{Linear}$$

Solution:

- In an AX_2 system (such as BeCl_2 or CO_2), the central atom forms two sigma bonding domains with zero non-bonding lone pairs.
- Mutual electrostatic repulsion pushes the domains to opposite sides, producing a linear geometry with a 180° bond angle.

Why other options are incorrect:

- Option A:** Bent (angular) geometry occurs when lone pairs are present on the central atom (e.g., AX_2E in SO_2 or AX_2E_2 in H_2O).
- Option B:** Trigonal planar geometry requires three bonding domains (AX_3) with 120° bond angles.
- Option D:** Tetrahedral geometry requires four bonding domains (AX_4) with 109.5° bond angles.

Question #120 Key: (C)

CHEMISTRY
07. Equilibrium

A colloidal dispersion consisting of microscopic droplets of one liquid dispersed uniformly thr...

CORE CONCEPT & DERIVATION

Colloidal systems are classified based on the physical states of the dispersed phase and the continuous dispersion medium.

Formula / Rule / Reaction:



Solution:

- An emulsion is a stable mixture of two immiscible liquids (such as oil and water).
- Common examples include milk (fat droplets dispersed in water) and mayonnaise, typically stabilized by an emulsifying agent.

Why other options are incorrect:

- Option A:** An aerosol consists of liquid or solid particles dispersed within a continuous gas medium (e.g., fog, smoke).
- Option B:** A sol consists of solid particles dispersed within a continuous liquid medium (e.g., paint, cell cytoplasm).
- Option D:** A gel consists of liquid particles trapped within a semi-rigid solid network (e.g., gelatin, jelly).

Question #121 Key: (B)CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Hydrocarbons containing one or more carbon-carbon double bonds or triple bonds in their chemical...

CORE CONCEPT & DERIVATION

Unsaturated hydrocarbons contain multiple bonds between carbon atoms and can undergo addition reactions.

Formula / Rule / Reaction:

Alkenes: C_nH_{2n} ($C = C$), Alkynes: C_nH_{2n-2} ($C \equiv C$)

Solution:

- Alkenes possess one or more carbon-carbon double bonds consisting of one sigma and one pi bond.
- Alkynes possess one or more carbon-carbon triple bonds consisting of one sigma and two pi bonds. Both are classified as unsaturated hydrocarbons.

Why other options are incorrect:

- Option A:** Alkanes and cycloalkanes contain only single sigma bonds and are fully saturated hydrocarbons.
- Option C:** Alkanes are saturated hydrocarbons; alkyl halides are halo-substituted saturated alkanes.
- Option D:** Alcohols and ethers are oxygenated organic functional classes, not pure hydrocarbons.

Question #122 Key: (B)CHEMISTRY
07. Equilibrium

According to the Bronsted-Lowry acid-base theory, the conjugate acid of ammonia ([Formula]) is...

CORE CONCEPT & DERIVATION

A conjugate acid is the chemical species formed when a Bronsted-Lowry base accepts a proton (H^+).

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

- Ammonia (NH_3) acts as a Bronsted base by using the lone pair on its nitrogen atom to accept a proton.
- Gaining an H^+ converts ammonia into its conjugate acid, the ammonium cation (NH_4^+).

Why other options are incorrect:

- Option A:** The amide ion (NH_2^-) is the conjugate base of ammonia, formed when ammonia loses a proton.
- Option C:** The imide ion (NH_2^{2-}) results from the loss of two protons from ammonia.
- Option D:** The nitride ion (N^{3-}) is an inorganic trianion, not the conjugate acid of ammonia.

Question #123 Key: (B)PHYSICS
14. Dawn of Modern Physics

The linear momentum ([Formula]) of a photon of frequency [Formula] traveling at the speed of...

CORE CONCEPT & DERIVATION

Photons are massless quanta of electromagnetic energy that carry momentum proportional to their frequency.

Formula / Rule / Reaction:

$$E = h\nu = pc \implies p = \frac{E}{c} = \frac{h\nu}{c} = \frac{h}{\lambda}$$

Solution:

- Einstein's relativistic relation gives the energy of a photon as $E = pc$.
- Equating this with Planck's quantum energy $E = h\nu$ and solving for momentum gives $p = \frac{h\nu}{c}$.

Why other options are incorrect:

- Option A:** $h\nu c$ is dimensionally incorrect for momentum (units of energy $\times$ velocity).
- Option C:** $\frac{c}{h\nu}$ is the reciprocal of photon momentum.
- Option D:** mc^2 is Einstein's rest mass-energy relation, not linear momentum.

Question #124 Key: (B)PHYSICS
09. Current Electricity

The SI derived unit of electrical resistance is the:

CORE CONCEPT & DERIVATION

Electrical resistance measures the opposition a conductor presents to the flow of electric current.

Formula / Rule / Reaction:

$$R = \frac{V}{I} \implies 1 \Omega = 1 \text{ V/A}$$

Solution:

- From Ohm's law, resistance is defined as the ratio of potential difference (volts) to current (amperes).
- In the SI system, resistance is measured in ohms (Ω).

Why other options are incorrect:

- Option A:** The volt (V) is the SI unit of electric potential difference and electromotive force.
- Option C:** The siemens (S) is the SI unit of electrical conductance (Ω^{-1}).
- Option D:** The ampere (A) is the SI base unit of electric current.

Question #125 Key: (C)PHYSICS
05. Waves

Which of the following wave phenomena is exhibited exclusively by transverse waves and cannot be...

CORE CONCEPT & DERIVATION

Polarization restricts wave oscillations to a single plane perpendicular to the direction of wave propagation.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In transverse waves (e.g., light), particle or field oscillations occur perpendicular to the direction of propagation, allowing them to be polarized into a single plane.
- In longitudinal waves (e.g., sound), oscillations occur parallel to the direction of propagation, meaning they possess radial symmetry along their axis of travel and cannot be polarized.

Why other options are incorrect:

- Option A:** Both transverse and longitudinal waves undergo reflection when encountering a boundary.
- Option B:** Both wave types undergo refraction when moving between media of differing wave speeds.
- Option D:** Both wave types undergo constructive and destructive interference following the principle of superposition.

Question #126 Key: (A)PHYSICS
14. Dawn of Modern Physics

If a mass of [Formula] is completely converted into energy, the total amount of energy released...

CORE CONCEPT & DERIVATION

Einstein's mass-energy equivalence principle relates the rest mass of an object directly to its equivalent energy content.

Formula / Rule / Reaction:

$$E = mc^2$$

Solution:

- Given mass $m = 1.0 \text{ kg}$ and speed of light $c = 3.0 \times 10^8 \text{ m/s}$:
- $E = (1.0 \text{ kg}) \times (3.0 \times 10^8 \text{ m/s})^2 = 1.0 \times (9.0 \times 10^{16}) = 9.0 \times 10^{16} \text{ Joules}$.

Why other options are incorrect:

- Option B:** $3 \times 10^8 \text{ J}$ reflects c rather than c^2 .
- Option C:** $9 \times 10^{10} \text{ J}$ represents a calculation error in the exponent.
- Option D:** $3 \times 10^{16} \text{ J}$ fails to square the coefficient 3 of the speed of light.

Question #127 Key: (A)PHYSICS
09. Current Electricity

The SI unit of electrical resistivity ([Formula]) of a conducting material is:

CORE CONCEPT & DERIVATION

Resistivity is an intrinsic property that quantifies how strongly a material opposes electric current, independent of its geometry.

Formula / Rule / Reaction:

$$R = \rho \frac{L}{A} \implies \rho = \frac{R \cdot A}{L} = \frac{\Omega \cdot \text{m}^2}{\text{m}} = \Omega \cdot \text{m}$$

Solution:

- Substituting the SI units of resistance (Ω), area (m^2), and length (m) into the formula yields:
- Unit of $\rho = \Omega \cdot \text{m}$ (ohm-meter).

Why other options are incorrect:

- Option B:** Ω/m is resistance per unit length.
- Option C:** $\Omega^{-1} \cdot \text{m}^{-1}$ (or $\text{S} \cdot \text{m}^{-1}$) is the SI unit of electrical conductivity (σ).
- Option D:** $\text{V} \cdot \text{m}$ is the unit of electric flux.

Question #128 Key: (B)PHYSICS
03. Work & Energy

The SI derived unit of power, defined as one joule of energy transferred per second, is the:

CORE CONCEPT & DERIVATION

Power is the rate at which work is done or energy is transferred per unit time.

Formula / Rule / Reaction:

$$P = \frac{W}{t} = \frac{\Delta E}{\Delta t} \implies 1 \text{ W} = 1 \text{ J/s}$$

Solution:

- In the International System of Units, the watt (W) is defined as one joule of work performed per second.
- In base units, it is expressed as $\text{kg} \cdot \text{m}^2 \cdot \text{s}^{-3}$.

Why other options are incorrect:

- Option A:** The joule (J) is the SI unit of work and energy, not power.
- Option C:** The newton (N) is the SI unit of force.
- Option D:** The pascal (Pa) is the SI unit of pressure.

Question #129 Key: (C)PHYSICS
13. Electronics

The total potential difference across a combination of three identical electric cells becomes $m \dots$

CORE CONCEPT & DERIVATION

Connecting voltage sources in series adds their individual electromotive forces along the circuit loop.

Formula / Rule / Reaction:

$$V_{\text{series}} = E_1 + E_2 + E_3 = 3E$$

Solution:

- When three identical cells of EMF E are connected in series-aiding configuration, their potentials sum directly: $V_{\text{total}} = 3E$.
- In contrast, connecting them in parallel yields a net EMF equal to only that of a single cell ($V_{\text{parallel}} = E$). Thus, the series arrangement provides the maximum potential difference.

Why other options are incorrect:

- Option A:** Connecting all three cells in parallel yields an equivalent EMF of only E .
- Option B:** Two cells in parallel produce E ; placed in series with the third, the total is $2E$, which is less than $3E$.
- Option D:** Two cells in series produce $2E$; connected in parallel with the third cell, circulating currents occur without increasing the maximum output voltage above $2E$.

Question #130 Key: (B)PHYSICS
11. Electromagnetic Induction

Which of the following statements is scientifically correct regarding an electrical transformer...

CORE CONCEPT & DERIVATION

Transformers transfer electrical energy between circuits through time-varying magnetic flux linkages across inductively coupled coils.

Formula / Rule / Reaction:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = \frac{I_p}{I_s}$$

Solution:

- An alternating current in the primary winding produces a continuously changing magnetic flux in the laminated iron core.
- By Faraday's law of mutual induction, this changing flux links with and induces an alternating voltage in the secondary winding.

Why other options are incorrect:

- Option A:** Converting DC to AC is performed by an electronic inverter, not a passive transformer.
- Option C:** Converting mechanical energy to electrical energy is performed by an electric generator.
- Option D:** A steady DC voltage produces static, constant magnetic flux ($\frac{d\Phi}{dt} = 0$), inducing zero voltage in the secondary coil and potentially overheating the primary winding.

Question #131 Key: (A)PHYSICS
02. Force & Motion

According to Newton's second law of motion, the time rate of change of linear momentum of a bod...

CORE CONCEPT & DERIVATION

Newton's second law states that the net unbalanced force acting on a body produces an acceleration proportional to the force.

Formula / Rule / Reaction:

$$\vec{F}_{\text{net}} = \frac{d\vec{p}}{dt} = \frac{d(m\vec{v})}{dt} = m\vec{a} \quad (\text{For constant mass})$$

Solution:

- Newton defined force as the time rate of change of momentum.
- An external net force changes an object's velocity, producing a rate of momentum change ($\frac{\Delta p}{\Delta t}$) equal in magnitude and direction to the applied force.

Why other options are incorrect:

- Option B:** Kinetic energy is the work capacity of a moving body ($\frac{1}{2}mv^2$), not the rate of change of momentum.
- Option C:** Applied torque is the time rate of change of angular momentum ($\tau = \frac{dL}{dt}$).
- Option D:** Impulse is the integral of force over time, which equals the total change in momentum ($J = \Delta p$), not its time rate of change.

Question #132 Key: (B)PHYSICS
02. Force & Motion

In ideal projectile motion (ignoring air resistance), the horizontal component of acceleration...

CORE CONCEPT & DERIVATION

Projectiles move under the influence of gravity alone, which acts exclusively downward along the vertical axis.

Formula / Rule / Reaction:

$$a_x = 0, \quad a_y = -g = -9.8 \text{ m/s}^2$$

Solution:

- When air drag is negligible, no force acts on the projectile along the horizontal axis ($F_x = 0$).
- By Newton's second law, $a_x = \frac{F_x}{m} = 0$. Consequently, the horizontal velocity component remains constant throughout the trajectory.

Why other options are incorrect:

- Option A:** 9.8 m/s^2 is the vertical acceleration due to gravity (a_y).
- Option C:** Launch angle determines initial horizontal and vertical velocity components, but horizontal acceleration remains zero regardless of angle.
- Option D:** Horizontal acceleration is zero, whereas vertical acceleration is non-zero ($-g$).

Question #133 Key: (A)PHYSICS
07. Thermodynamics

Which of the following thermodynamic statements is correct?

CORE CONCEPT & DERIVATION

By the second law of thermodynamics (Kelvin-Planck statement), work can be fully dissipated into heat, but heat cannot be converted 100% into work in a cyclic process.

Formula / Rule / Reaction:

$$\text{Work} \xrightarrow{100\%} \text{Heat (e.g., via friction)}; \quad \eta = 1 - \frac{T_C}{T_H} < 100\% \text{ for Heat Engines}$$

Solution:

- Mechanical work can be converted entirely into thermal internal energy (heat) via frictional dissipation or electrical resistance heating without thermodynamic restriction.
- In contrast, heat cannot be converted completely into useful work in a cyclic engine without rejecting some waste heat to a colder reservoir.

Why other options are incorrect:

- Option B:** The Kelvin-Planck statement of the Second Law explicitly forbids 100% conversion of heat into work in a cyclic process.
- Option C:** Work is readily converted into heat through friction and viscous dissipation.
- Option D:** Heat and work are both path-dependent modes of energy transfer across system boundaries and are interconvertible.

Question #134 Key: (C)PHYSICS
05. Waves

The restoring force responsible for producing simple harmonic motion in a simple pendulum of mass m is...

CORE CONCEPT & DERIVATION

The restoring force of a simple pendulum is the component of gravity directed tangent to the circular arc toward the equilibrium position.

Formula / Rule / Reaction:

$$F_{\text{restoring}} = -mg \sin \theta \approx -mg\theta = -mg \left(\frac{x}{L} \right) \quad (\text{For small angles})$$

Solution:

- Resolving the gravitational weight vector (mg) shows that $mg \cos \theta$ balances the string tension along the radial axis.
- The tangential component acting perpendicular to the string is $mg \sin \theta$, which pulls the bob back toward the central rest position.

Why other options are incorrect:

- Option A:** $mg \cos \theta$ acts along the string and is balanced by the tension force.
- Option B:** $mg \tan \theta$ is the horizontal component in a conical pendulum, not the restoring force of a simple planar pendulum.
- Option D:** $mg \sin^2 \theta$ is dimensionally non-linear and physically incorrect.

Question #135 Key: (B)PHYSICS
09. Current Electricity

"The electric current flowing through a metallic conductor is directly proportional to the potential difference across it."

CORE CONCEPT & DERIVATION

Georg Simon Ohm formulated the foundational constitutive relationship governing steady current flow through linear ohmic conductors.

Formula / Rule / Reaction:

$$I \propto V \implies V = IR \quad (\text{At constant } T)$$

Solution:

- Ohm's law states that current is directly proportional to voltage when temperature and dimensions remain unchanged.
- The constant of proportionality is the electrical resistance (R).

Why other options are incorrect:

- Option A:** Coulomb's law describes the electrostatic force between two stationary electric charges.
- Option C:** Faraday's law relates induced electromotive force to the time rate of change of magnetic flux.
- Option D:** Ampere's circuital law relates the line integral of magnetic field around a closed loop to the enclosed electric current.

Question #136 Key: (C)PHYSICS
08. Electrostatics

The electrical energy transferred or work done per unit electric charge moved between two points is called the potential difference.

CORE CONCEPT & DERIVATION

Electric potential difference is defined as the work done in moving a unit positive charge between two points against an electrostatic field.

Formula / Rule / Reaction:

$$\Delta V = \frac{W}{q} = \frac{\Delta U}{q} \implies 1 \text{ Volt} = 1 \text{ Joule/Coulomb}$$

Solution:

- Potential difference measures the energy lost or gained per unit charge as it traverses a circuit element.
- Dividing the work done (joules) by the quantity of charge transferred (coulombs) defines voltage (volts).

Why other options are incorrect:

- Option A:** Electric resistance measures the opposition to current flow, expressed in ohms (V/A).
- Option B:** Electric capacitance is the ratio of stored charge to potential difference ($C = Q/V$), expressed in farads.
- Option D:** Electric power is the rate of energy transfer per unit time ($P = W/t$), expressed in watts.

Question #137 Key: (B)

PHYSICS
15. Atomic Spectra

In the atomic emission spectrum of hydrogen, electronic transitions terminating at the second p...

CORE CONCEPT & DERIVATION

Hydrogen spectral series are categorized by the principal quantum number of the lower energy level to which excited electrons transition.

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{2^2} - \frac{1}{n_2^2} \right) \quad \text{where } n_2 = 3, 4, 5, \dots$$

Solution:

- Transitions from higher levels ($n_2 \geq 3$) down to $n_1 = 2$ emit photons in the visible spectrum.
- This emission group is named the Balmer series, containing prominent lines such as H_α (656 nm) and H_β (486 nm).

Why other options are incorrect:

- Option A:** The Lyman series involves transitions terminating at $n_1 = 1$, emitting in the ultraviolet region.
- Option C:** The Paschen series involves transitions terminating at $n_1 = 3$, emitting in the near-infrared region.
- Option D:** The Brackett series involves transitions terminating at $n_1 = 4$, emitting in the infrared region.

Question #138 Key: (C)

PHYSICS
10. Electromagnetism

The magnitude of the magnetic force ([Formula]) experienced by a straight conductor of length...

CORE CONCEPT & DERIVATION

The magnetic force on a current-carrying wire is the vector sum of the magnetic Lorentz forces acting on all conduction electrons moving through the conductor.

Formula / Rule / Reaction:

$$\vec{F} = I(\vec{L} \times \vec{B}) \implies F = BIL \sin \theta$$

Solution:

- The magnetic force depends directly on the magnetic flux density (B), the current (I), the length of the conductor within the field (L), and the sine of the angle θ between the conductor and the magnetic field lines.
- This force is maximized when the conductor is oriented perpendicular to the field ($\theta = 90^\circ$).

Why other options are incorrect:

- Option A:** $qvB \sin \theta$ is the Lorentz force acting on a single isolated moving charge, not a macroscopic conductor.
- Option B:** Uses $\cos \theta$, which erroneously implies maximum force when the wire is parallel to the field.
- Option D:** Divides by $\sin \theta$, which is dimensionally and physically incorrect.

Question #139 Key: (B)

PHYSICS
07. Thermodynamics

The ratio of the universal molar gas constant ([Formula]) to Avogadro's number ([Formula])...

CORE CONCEPT & DERIVATION

The Boltzmann constant represents the gas constant per individual molecule rather than per mole of gas.

Formula / Rule / Reaction:

$$k_B = \frac{R}{N_A} = \frac{8.314 \text{ J} \cdot \text{mol}^{-1} \cdot \text{K}^{-1}}{6.022 \times 10^{23} \text{ mol}^{-1}} = 1.38 \times 10^{-23} \text{ J/K}$$

Solution:

- Dividing the molar gas constant R by the number of molecules per mole (N_A) gives the Boltzmann constant (k_B).
- It links microscopic average kinetic energy directly to absolute temperature: $\bar{E}_k = \frac{3}{2} k_B T$.

Why other options are incorrect:

- Option A:** Planck's constant ($h = 6.626 \times 10^{-34} \text{ J} \cdot \text{s}$) relates photon energy to frequency.
- Option C:** The Rydberg constant ($R_H \approx 1.097 \times 10^7 \text{ m}^{-1}$) describes atomic emission wavelengths in hydrogen.
- Option D:** The Stefan-Boltzmann constant ($\sigma = 5.67 \times 10^{-8} \text{ W} \cdot \text{m}^{-2} \cdot \text{K}^{-4}$) relates blackbody radiant emittance to absolute temperature.

Question #140 Key: (B)

PHYSICS
08. Electrostatics

The electrostatic force of attraction or repulsion between two stationary point charges is dir...

CORE CONCEPT & DERIVATION

Charles-Augustin de Coulomb formulated the inverse-square law governing electrostatic forces between static point charges in a vacuum.

Formula / Rule / Reaction:

$$F = k \frac{|q_1 q_2|}{r^2} = \frac{1}{4\pi\epsilon_0} \frac{|q_1 q_2|}{r^2}$$

Solution:

- Coulomb's law states that the electrostatic force acting along the line joining two stationary point charges is proportional to $q_1 q_2$ and inversely proportional to r^2 .
- In a vacuum, the proportionality constant is $k \approx 8.99 \times 10^9 \text{ N} \cdot \text{m}^2/\text{C}^2$.

Why other options are incorrect:

- Option A:** Gauss's law relates total electric flux through a closed surface to the net enclosed charge.
- Option C:** Ampere's law relates line integrals of magnetic fields to enclosed electric currents.
- Option D:** Faraday's law describes the induction of electromotive force by time-varying magnetic flux.

Question #141 Key: (A)PHYSICS
16. Nuclear Physics

In nuclear physics, the product of the half-life ([Formula]) of a radioisotope and its decay ...

CORE CONCEPT & DERIVATION

The statistical rate of radioactive disintegration follows first-order exponential decay kinetics.

Formula / Rule / Reaction:

$$N(t) = N_0 e^{-\lambda t} \Rightarrow \frac{N_0}{2} = N_0 e^{-\lambda T_{1/2}} \Rightarrow T_{1/2} \cdot \lambda = \ln(2) \approx 0.693$$

Solution:

- Taking the natural logarithm of 2 yields:
- $\ln(2) = 0.693147 \dots \approx 0.693$. Thus, the product of half-life and decay constant is always constant and equal to 0.693.

Why other options are incorrect:

- **Option B:** 0.369 is a transposed distractor.
- **Option C:** 1.440 is the ratio of mean lifetime to half-life ($\tau/T_{1/2} = 1/\ln(2) \approx 1.443$).
- **Option D:** 0.500 is the fraction of undecayed nuclei remaining after exactly one half-life, not the product $T_{1/2} \cdot \lambda$.

Question #142 Key: (B)PHYSICS
08. Electrostatics

The work done in moving a unit positive test charge from one point to another against an electr...

CORE CONCEPT & DERIVATION

Electric potential difference is the scalar work required to move charge through an electrostatic field without acceleration.

Formula / Rule / Reaction:

$$\Delta V = V_B - V_A = \frac{W_{A \rightarrow B}}{q_0} = - \int_A^B \vec{E} \cdot d\vec{r}$$

Solution:

- Electric potential difference between two points is defined as the work done by an external agent in moving a unit positive charge between those points against electric forces.
- It is expressed in joules per coulomb, or volts.

Why other options are incorrect:

- **Option A:** Electric field intensity ($\vec{E}$) is the electrostatic force experienced per unit charge ($\vec{E}/q$), a vector measured in N/C or V/m.
- **Option C:** Electric permittivity (ϵ) measures the resistance of a dielectric medium to electric field formation.
- **Option D:** Capacitance ($C = Q/V$) measures charge storage capacity per unit potential difference.

Question #143 Key: (C)PHYSICS
10. Electromagnetism

Which of the following statements is correct regarding the magnetic force exerted on a charged ...

CORE CONCEPT & DERIVATION

The magnetic Lorentz force on a moving charge depends on the cross product of its velocity vector with the magnetic flux density vector.

Formula / Rule / Reaction:

$$\vec{F} = q(\vec{v} \times \vec{B}) \Rightarrow F = qvB \sin \theta$$

Solution:

- When the velocity is perpendicular to the magnetic field ($\theta = 90^\circ$), $\sin(90^\circ) = 1$, maximizing the magnetic force: $F_{\max} = qvB$.
- When moving parallel to the field ($\theta = 0^\circ$), $\sin(0^\circ) = 0$, and the magnetic force is zero.

Why other options are incorrect:

- **Option A:** When moving parallel, $\theta = 0^\circ$, so the force is zero rather than maximum.
- **Option B:** When moving perpendicular, the force is at its maximum value, not zero.
- **Option D:** Stationary charges ($v = 0$) and charges moving parallel ($\theta = 0^\circ, 180^\circ$) experience zero magnetic force.

Question #144 Key: (C)PHYSICS
09. Current Electricity

The electrical resistivity ([Formula]) of a metallic conductor depends intrinsically on the:

CORE CONCEPT & DERIVATION

Resistivity is an intrinsic intensive material property determined by free electron density, relaxation time, and thermal lattice scattering.

Formula / Rule / Reaction:

$$\rho = \frac{m}{ne^2\tau}, \quad \rho(T) = \rho_0[1 + \alpha(T - T_0)]$$

Solution:

- Resistivity depends only on the microscopic composition of the metal (free electron density n and mean free time between collisions τ) and its operating temperature.
- Unlike resistance, resistivity is independent of conductor length, thickness, or geometric shape.

Why other options are incorrect:

- **Option A:** Length changes total resistance ($R \propto L$), but not the intrinsic material resistivity.
- **Option B:** Cross-sectional area changes resistance ($R \propto 1/A$), but leaves resistivity unaffected.
- **Option D:** Shape and volume alter macroscopic resistance, not material resistivity.

Question #145 Key: (A)PHYSICS
12. Alternating Current

The speed of propagation of electromagnetic waves ([Formula]) in free space (vacuum) is appro...

CORE CONCEPT & DERIVATION

Maxwell's equations show that electromagnetic waves propagate through a vacuum at a constant speed determined by free-space permittivity and permeability.

Formula / Rule / Reaction:

$$c = \frac{1}{\sqrt{\epsilon_0 \mu_0}} = 2.99792458 \times 10^8 \text{ m/s} \approx 3 \times 10^8 \text{ m/s}$$

Solution:

- All electromagnetic radiation, including visible light, X-rays, and radio waves, travels through a vacuum at the speed of light.
- In SI units, this fundamental constant is approximately $3 \times 10^8 \text{ m/s}$.

Why other options are incorrect:

- Option B:** $3 \times 10^6 \text{ m/s}$ is two orders of magnitude too slow.
- Option C:** $3 \times 10^{10} \text{ m/s}$ is two orders of magnitude too fast (though $3 \times 10^{10} \text{ cm/s}$ in CGS units).
- Option D:** $3 \times 10^5 \text{ m/s}$ is approximately 300 km/s, three orders of magnitude below c .

Question #146 Key: (C)PHYSICS
03. Work & Energy

A machine operating at a constant power output of [Formula] delivers how much total energy in [...]

CORE CONCEPT & DERIVATION

Energy delivered by a constant power source is the product of power and elapsed time in seconds.

Formula / Rule / Reaction:

$$E = P \times t$$

Solution:

- Given power $P = 6 \text{ W}$ and time $t = 2 \text{ minutes}$:
- Convert time to SI seconds: $t = 2 \times 60 = 120 \text{ seconds}$.
- Calculate total energy: $E = 6 \text{ W} \times 120 \text{ s} = 720 \text{ Joules}$.

Why other options are incorrect:

- Option A:** 12 J results from failing to convert minutes into seconds ($6 \times 2 = 12$).
- Option B:** 120 J reflects the time in seconds without multiplying by power.
- Option D:** 360 J corresponds to an operation time of only 1 minute.

Question #147 Key: (D)PHYSICS
07. Thermodynamics

A thermodynamic process occurring at constant temperature during which all heat supplied to an ...

CORE CONCEPT & DERIVATION

In an isothermal process involving an ideal gas, internal energy remains constant because temperature does not change.

Formula / Rule / Reaction:

$$\Delta U = nC_v \Delta T = 0 \implies Q = W$$

Solution:

- By the first law of thermodynamics, $Q = \Delta U + W$.
- For an ideal gas undergoing an isothermal expansion ($\Delta T = 0$), internal energy does not change ($\Delta U = 0$). Thus, all supplied heat is converted into boundary work: $Q = W$.

Why other options are incorrect:

- Option A:** In an isochoric process (constant volume), $W = 0$, so all heat increases internal energy ($Q = \Delta U$).
- Option B:** In an isobaric process (constant pressure), heat divides between internal energy and work ($Q = \Delta U + P\Delta V$).
- Option C:** In an adiabatic process, no heat is exchanged with surroundings ($Q = 0$), and work is done at the expense of internal energy.

Question #148 Key: (A)PHYSICS
08. Electrostatics

The charge-to-mass ratio ([Formula]) of an electron is approximately:

CORE CONCEPT & DERIVATION

The specific charge of an electron was first measured by J.J. Thomson in 1897 using balanced electric and magnetic deflection fields.

Formula / Rule / Reaction:

$$\frac{e}{m_e} = \frac{1.602 \times 10^{-19} \text{ C}}{9.109 \times 10^{-31} \text{ kg}} = 1.7588 \times 10^{11} \text{ C/kg} \approx 1.76 \times 10^{11} \text{ C/kg}$$

Solution:

- Dividing the elementary charge by the electron rest mass gives:
- $\frac{e}{m_e} = 1.76 \times 10^{11} \text{ Coulombs per kilogram}$.

Why other options are incorrect:

- Option B:** $1.602 \times 10^{-19} \text{ C}$ is the charge of an electron, not its charge-to-mass ratio.
- Option C:** $9.11 \times 10^{-31} \text{ kg}$ is the rest mass of an electron.
- Option D:** $1.76 \times 10^8 \text{ C/g}$ represents the ratio in CGS units (coulombs per gram), not SI units.

Question #149 Key: (B)PHYSICS
02. Force & Motion

When the instantaneous velocity of a moving body is equal to its average velocity over any given...

CORE CONCEPT & DERIVATION

A body moves with uniform velocity when both the magnitude and direction of its displacement change at a constant rate over time.

Formula / Rule / Reaction:

$$\vec{v}_{\text{inst}} = \frac{d\vec{r}}{dt} = \vec{v}_{\text{avg}} = \frac{\Delta\vec{r}}{\Delta t} = \text{Constant} \implies \vec{a} = 0$$

Solution:

- If instantaneous velocity equals average velocity across any arbitrary time interval, velocity cannot be varying at any instant.
- Therefore, the body travels in a straight line at constant speed, representing uniform velocity with zero acceleration.

Why other options are incorrect:

- **Option A:** In uniformly accelerated motion, velocity changes continuously, so instantaneous velocity varies from point to point and does not equal overall average velocity.
- **Option C:** Variable acceleration produces non-linear, fluctuating velocity-time profiles.
- **Option D:** Non-zero jerk means acceleration is changing over time, which causes velocity to vary continuously.

Question #150 Key: (B)PHYSICS
05. Waves

Waves that strictly require a material medium (solid, liquid, or gas) for their transmission an...

CORE CONCEPT & DERIVATION

Mechanical waves transmit energy through oscillating particles of an elastic medium linked by intermolecular forces.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Mechanical waves (such as acoustic sound waves, seismic waves, and water waves) rely on the inertial and elastic properties of physical matter.
- Because a vacuum lacks material particles to sustain mechanical vibrations, mechanical waves cannot propagate through it.

Why other options are incorrect:

- **Option A:** Electromagnetic waves consist of oscillating electric and magnetic fields that propagate through a vacuum without needing a material medium.
- **Option C:** Matter waves (de Broglie waves) describe the quantum wave nature of moving material particles.
- **Option D:** Photonic waves are electromagnetic quanta that propagate freely through empty space.

Question #151 Key: (B)PHYSICS
08. Electrostatics

The SI unit of electric field intensity is:

CORE CONCEPT & DERIVATION

Electric field intensity is the electrostatic force experienced per unit positive test charge placed at a given point in space.

Formula / Rule / Reaction:

$$\vec{E} = \frac{\vec{F}}{q_0} \implies 1 \text{ N/C} = 1 \text{ V/m}$$

Solution:

- Force is measured in newtons (N) and charge is measured in coulombs (C).
- Dividing force by charge yields newtons per coulomb ($\text{N} \cdot \text{C}^{-1}$), which is equivalent to volts per meter (V/m).

Why other options are incorrect:

- **Option A:** $\text{J} \cdot \text{C}^{-2}$ is dimensionally equivalent to V/C , which is not electric field strength.
- **Option C:** $\text{N} \cdot \text{m}^2 \cdot \text{C}^{-1}$ is the SI unit of electric flux (Φ_E).
- **Option D:** $\text{C} \cdot \text{N}^{-2}$ has inverted, squared physical dimensions.

Question #152 Key: (C)PHYSICS
10. Electromagnetism

An electron and a proton enter a uniform magnetic field perpendicularly with the same linear mo...

CORE CONCEPT & DERIVATION

The radius of curvature for a charged particle moving perpendicular to a uniform magnetic field depends directly on its linear momentum.

Formula / Rule / Reaction:

$$r = \frac{mv}{qB} = \frac{p}{qB}$$

Solution:

- Both the electron and proton have the same magnitude of electric charge ($|q| = e$) and enter the same magnetic field (B).
- Because their linear momenta (p) are identical, the radius of curvature $r = \frac{p}{qB}$ is identical for both particles. Although they curve in opposite directions due to opposite signs of charge, the magnitude of deflection is equal.

Why other options are incorrect:

- **Option A:** Charged particles entering perpendicularly experience a nonzero magnetic Lorentz force and must deflect into circular arcs.
- **Option B:** The electron would have a smaller radius only if entering with equal velocity, not equal momentum.
- **Option D:** The proton has the same trajectory radius because momentum, not mass alone, governs the path radius.

Question #153 Key: (A)PHYSICS
02. Force & Motion

A body starts from rest and falls freely under gravity. The distance covered by it in [Formula]...

CORE CONCEPT & DERIVATION

Under constant gravitational acceleration with zero initial velocity, displacement increases quadratically with elapsed time.

Formula / Rule / Reaction:

$$S = v_i t + \frac{1}{2} g t^2 \quad \text{with } v_i = 0 \implies S = \frac{1}{2} g t^2 = 0.5 g t^2$$

Solution:

- Starting from rest implies initial velocity $v_i = 0$.
- Substituting $v_i = 0$ into the second equation of motion simplifies the equation directly to $S = 0.5 g t^2$.

Why other options are incorrect:

- Option B:** $g t$ is the instantaneous velocity acquired after time t , not the distance fallen.
- Option C:** $0.5 g t$ is dimensionally incorrect for distance.
- Option D:** $g^2 t^2$ is dimensionally equivalent to squared velocity (m^2/s^2).

Question #154 Key: (B)PHYSICS
05. Waves

The total mechanical energy [Formula] of a mass-spring system executing simple harmonic motion...

CORE CONCEPT & DERIVATION

In an undamped simple harmonic oscillator, total mechanical energy is conserved and proportional to the square of the amplitude.

Formula / Rule / Reaction:

$$E_{\text{total}} = K + U = \frac{1}{2} m v^2 + \frac{1}{2} k x^2 = \frac{1}{2} k x_0^2 = 0.5 k x_0^2$$

Solution:

- At maximum displacement (amplitude x_0), kinetic energy is zero and potential energy is $\frac{1}{2} k x_0^2$.
- Because total energy is conserved throughout the oscillation, $E = 0.5 k x_0^2$ at all points in the cycle. Note: In source exams where written as $0.5 k x^2$, this refers to the potential energy term at displacement x .

Why other options are incorrect:

- Option A:** Energy is a positive scalar quantity and cannot be negative.
- Option C:** Potential energy cannot be negative in a mass-spring system where $U = +\frac{1}{2} k x^2$.
- Option D:** $k x$ is the magnitude of the restoring force according to Hooke's law, not energy.

Question #155 Key: (C)PHYSICS
13. Electronics

A reverse-biased p-n junction semiconductor diode behaves essentially as an:

CORE CONCEPT & DERIVATION

Reverse biasing widens the depletion layer and increases the potential barrier, blocking majority carrier diffusion.

Formula / Rule / Reaction:

$$R_{\text{reverse}} \approx 10^6 \Omega \implies I \approx I_s \approx 0 \implies \text{Open Circuit}$$

Solution:

- Connecting the positive battery terminal to the n-region and negative terminal to the p-region pulls majority carriers away from the junction.
- This creates an extremely high electrical resistance path with negligible minority leakage current, acting effectively as an open circuit (off switch).

Why other options are incorrect:

- Option A:** A forward-biased diode has low resistance and conducts current freely, behaving as an on switch.
- Option B:** An inverter is an active logic gate or circuit, not a passive two-terminal diode.
- Option D:** Amplification requires a three-terminal active device such as a bipolar junction transistor or operational amplifier.

Question #156 Key: (D)PHYSICS
03. Work & Energy

For maximum work done by a constant force, the angle between the force vector and displacement...

CORE CONCEPT & DERIVATION

Work done by a constant force is the scalar dot product of the force and displacement vectors.

Formula / Rule / Reaction:

$$W = \vec{F} \cdot \vec{d} = F d \cos \theta$$

Solution:

- The cosine function reaches its maximum positive value of 1 when $\theta = 0^\circ$.
- Therefore, work is maximized ($W_{\text{max}} = F d$) when force acts in the exact direction of displacement.

Why other options are incorrect:

- Option A:** At 45° , $\cos(45^\circ) = \frac{1}{\sqrt{2}} \approx 0.707$, yielding only 70.7% of maximum work.
- Option B:** At 90° , $\cos(90^\circ) = 0$, resulting in zero work done.
- Option C:** At 65° , $\cos(65^\circ) \approx 0.423$, yielding less than half of maximum work.

Question #157 Key: (B)PHYSICS
04. Rotational & Circular Motion

A body moves along a circular path with constant speed. Which of the following statements is true...

CORE CONCEPT & DERIVATION

Uniform circular motion involves continuous changes in velocity direction, requiring a centripetal force directed toward the center of curvature.

Formula / Rule / Reaction:

$$F_c = \frac{mv^2}{r} \quad (\text{Directed radially inward})$$

Solution:

- Even though speed is constant, the velocity vector continuously changes direction along the tangent.
- By Newton's first and second laws, this directional acceleration requires an unbalanced centripetal force directed radially inward toward the center of the circle.

Why other options are incorrect:

- **Option A:** A tangential force would change the speed of the body, violating the condition of constant speed.
- **Option C:** The body experiences centripetal acceleration ($a_c = v^2/r$) due to continuous changes in velocity direction.
- **Option D:** The net force cannot be zero because the velocity vector is not constant.

Question #158 Key: (C)PHYSICS
08. Electrostatics

The SI unit of electric potential difference is the:

CORE CONCEPT & DERIVATION

Electric potential difference is the work required per unit charge to move charge between two points in an electric field.

Formula / Rule / Reaction:

$$V = \frac{W}{q} \implies 1 \text{ Volt} = 1 \text{ Joule/Coulomb}$$

Solution:

- Named in honor of Alessandro Volta, the volt (V) is the derived SI unit of electric potential and electromotive force.
- One volt equals one joule of energy per coulomb of charge.

Why other options are incorrect:

- **Option A:** The ampere is the SI base unit of electric current.
- **Option B:** The coulomb is the SI derived unit of electric charge.
- **Option D:** The watt is the SI derived unit of power.

Question #159 Key: (A)PHYSICS
07. Thermodynamics

In the SI system of units, specific heat capacity ([Formula]) is measured in:

CORE CONCEPT & DERIVATION

Specific heat capacity is the amount of heat energy required to raise the temperature of one kilogram of a substance by one kelvin.

Formula / Rule / Reaction:

$$Q = mc\Delta T \implies c = \frac{Q}{m\Delta T} = \frac{\text{J}}{\text{kg} \cdot \text{K}} = \text{J} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$$

Solution:

- Heat Q is in joules (J), mass m is in kilograms (kg), and temperature change ΔT is in kelvins (K).
- Combining these gives $\text{J} \cdot \text{kg}^{-1} \cdot \text{K}^{-1}$.

Why other options are incorrect:

- **Option B:** $\text{J} \cdot \text{kg}$ has incorrect physical dimensions.
- **Option C:** Omits the reciprocal temperature exponent and uses Celsius rather than standard SI base Kelvin units.
- **Option D:** Uses non-standard grams instead of SI kilograms.

Question #160 Key: (B)PHYSICS
04. Rotational & Circular Motion

The time period ([Formula]) of uniform circular motion is related to angular frequency ([Formula]) as:

CORE CONCEPT & DERIVATION

The period is the duration of one complete circular revolution corresponding to an angular displacement of 2π radians.

Formula / Rule / Reaction:

$$\omega = \frac{\Delta\theta}{\Delta t} = \frac{2\pi}{T} \implies T = \frac{2\pi}{\omega}$$

Solution:

- Angular velocity ω is measured in radians per second.
- Dividing one complete revolution (2π radians) by ω gives the period $T = \frac{2\pi}{\omega}$.

Why other options are incorrect:

- **Option A:** $\frac{\omega}{2\pi}$ is the rotational frequency f , which is the reciprocal of period ($f = 1/T$).
- **Option C:** Multiplies by angular velocity rather than dividing, which is dimensionally incorrect.
- **Option D:** Contains an extraneous squared angular velocity term.

Question #161 Key: (C)PHYSICS
14. Dawn of Modern Physics

In the photoelectric threshold relationship [Formula], the physical symbol [Formula] represent...

CORE CONCEPT & DERIVATION

The work function is the minimum energy required to liberate an electron from the Fermi level of a metal surface into vacuum.

Formula / Rule / Reaction:

$$\Phi = h\nu_0 = \frac{hc}{\lambda_0}$$

Solution:

- In Einstein's photoelectric theory, Φ (or W_0) denotes the work function of the emitter surface.
- It equals the product of Planck's constant (h) and the threshold cutoff frequency (ν_0).

Why other options are incorrect:

- **Option A:** Magnetic flux is denoted by Φ_B and measured in webers (Wb), describing magnetic field lines through an area.
- **Option B:** Threshold frequency is represented by ν_0 or f_0 , measured in hertz.
- **Option D:** Electric flux is denoted by Φ_E and measured in $\text{N} \cdot \text{m}^2/\text{C}$.

Question #162 Key: (D)PHYSICS
09. Current Electricity

The base physical definition of electric current gives its unit as amperes, which is equivalent...

CORE CONCEPT & DERIVATION

Electric current is the net rate of electric charge flow past a given cross-section of a conductor.

Formula / Rule / Reaction:

$$I = \frac{\Delta Q}{\Delta t} \Rightarrow 1 \text{ Ampere} = 1 \text{ Coulomb/second}$$

Solution:

- One ampere represents the flow of one coulomb of electric charge per second through a conducting boundary.

Why other options are incorrect:

- **Option A:** Volts per second measures the rate of change of potential difference.
- **Option B:** Ohms per second has no standard physical application.
- **Option C:** Joules per second defines the watt (unit of power).

Question #163 Key: (C)PHYSICS
16. Nuclear Physics

Fast-moving electrons abruptly decelerated upon striking a heavy metallic target in an evacuate...

CORE CONCEPT & DERIVATION

Rapid deceleration of charged particles generates high-energy braking radiation known as Bremsstrahlung.

Formula / Rule / Reaction:

$$eV = h\nu_{\max} = \frac{hc}{\lambda_{\min}}$$

Solution:

- When high-velocity electrons strike a heavy metal target (such as tungsten), their kinetic energy is converted into electromagnetic radiation.
- This deceleration produces continuous Bremsstrahlung alongside characteristic X-ray lines.

Why other options are incorrect:

- **Option A:** Beta rays are high-speed electrons or positrons emitted spontaneously from unstable atomic nuclei during radioactive decay.
- **Option B:** Gamma rays are nuclear electromagnetic emissions originating from nuclear de-excitations.
- **Option D:** Alpha rays are helium nuclei (two protons and two neutrons) emitted during alpha decay.

Question #164 Key: (D)PHYSICS
11. Electromagnetic Induction

The instantaneous alternating electromotive force ([Formula]) generated by an AC generator of...

CORE CONCEPT & DERIVATION

Rotating a conductive loop inside a uniform magnetic field produces a sinusoidal variation in magnetic flux linkage, inducing an alternating voltage.

Formula / Rule / Reaction:

$$\Phi(t) = BA \cos(\omega t) \Rightarrow \mathcal{E} = -N \frac{d\Phi}{dt} = NAB\omega \sin(\omega t)$$

Solution:

- Applying Faraday's law to the changing flux linkage $N\Phi = NBA \cos(\omega t)$ yields:
- $\mathcal{E}(t) = \mathcal{E}_0 \sin(\omega t)$, where peak voltage $\mathcal{E}_0 = NAB\omega$.

Why other options are incorrect:

- **Option A:** $BvL \sin \theta$ describes motional EMF induced across a single straight conductor moving linearly through a field.
- **Option B:** Omits both the coil area A and the angular velocity ω .
- **Option C:** Fails to include the angular velocity ω and coil area A .

Question #165 Key: (C)PHYSICS
13. Electronics

In an n-type semiconductor material, the minority charge carriers are:

CORE CONCEPT & DERIVATION

Doping tetravalent semiconductors with pentavalent donor impurities produces an excess of conduction electrons, leaving thermally generated holes as minority carriers.

Formula / Rule / Reaction:

$$n_e \cdot n_h = n_i^2 \quad \text{with } n_e \gg n_h \text{ in n-type}$$

Solution:

- In an n-type semiconductor, donor atoms contribute large numbers of conduction electrons, which serve as majority carriers.
- Valence band holes generated exclusively by thermal electron-hole pair generation are present in much lower concentrations, making them the minority carriers.

Why other options are incorrect:

- Option A:** Photons are quanta of light energy, not electrical charge carriers in a semiconductor lattice.
- Option B:** Free electrons are the majority charge carriers in n-type semiconductors.
- Option D:** Protons are bound within atomic nuclei and do not act as mobile charge carriers.

Question #166 Key: (D)PHYSICS
16. Nuclear Physics

If the total binding energy of a deuteron ([Formula]) nucleus is [Formula], its binding ener...

CORE CONCEPT & DERIVATION

Binding energy per nucleon measures average nuclear stability, calculated by dividing total binding energy by mass number A .

Formula / Rule / Reaction:

$$\text{BE per nucleon} = \frac{E_b}{A}$$

Solution:

- A deuteron nucleus (${}^2_1\text{H}$) contains 1 proton and 1 neutron, giving mass number $A = 2$.
- Dividing total binding energy by the nucleon count gives: $\frac{2.3 \text{ MeV}}{2} = 1.15 \text{ MeV/nucleon}$ (often rounded to 1.1 MeV).

Why other options are incorrect:

- Option A:** 0.51 MeV is the rest mass energy of an electron.
- Option B:** 2.30 MeV is the total binding energy of the entire nucleus.
- Option C:** 1.02 MeV is the threshold photon energy required for electron-positron pair production.

Question #167 Key: (A)PHYSICS
10. Electromagnetism

The mathematical relationship between magnetic flux ([Formula]) and magnetic flux density ([Formula]) is...

CORE CONCEPT & DERIVATION

Magnetic flux is the surface integral of the normal component of magnetic flux density passing through a given surface area.

Formula / Rule / Reaction:

$$\Phi = \vec{B} \cdot \vec{A} = BA \cos \theta$$

Solution:

- Magnetic flux is the dot product of the magnetic field vector $\vec{B}$ and the area vector $\vec{A}$.
- Here, θ is the angle between the magnetic field lines and the vector normal to the surface plane.

Why other options are incorrect:

- Option B:** Replaces area A with time Δt , which is dimensionally incorrect.
- Option C:** Relates magnetic field incorrectly to flux and time.
- Option D:** Uses $\sin \theta$, which defines the angle relative to the plane surface rather than the standard surface normal.

Question #168 Key: (D)PHYSICS
05. Waves

If the length of a simple pendulum is increased by four times, its frequency of oscillation wil...

CORE CONCEPT & DERIVATION

The frequency of a simple pendulum is inversely proportional to the square root of its effective length.

Formula / Rule / Reaction:

$$f = \frac{1}{2\pi} \sqrt{\frac{g}{L}} \Rightarrow f \propto \frac{1}{\sqrt{L}}$$

Solution:

- Let the new length be $L' = 4L$.
- The new frequency is $f' = \frac{1}{2\pi} \sqrt{\frac{g}{4L}} = \frac{1}{\sqrt{4}} \left(\frac{1}{2\pi} \sqrt{\frac{g}{L}} \right) = \frac{1}{2}f$. Thus, the frequency decreases by a factor of 2.

Why other options are incorrect:

- Option A:** Frequency decreases rather than increases when length is lengthened.
- Option B:** The factor is 2 because of the square root dependence, not 4.
- Option C:** Frequency depends directly on length and cannot remain unchanged.

Question #169 Key: (B)

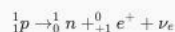
PHYSICS
16. Nuclear Physics

In the beta-plus nuclear decay equation [Formula], the emitted particle [Formula] is a:

CORE CONCEPT & DERIVATION

Beta-plus decay converts an intra-nuclear proton into a neutron, conserving charge via the emission of a positron and an electron neutrino.

Formula / Rule / Reaction:



Solution:

- Conservation of charge requires $+1 = 0 + Z_X + 0 \Rightarrow Z_X = +1$.
- Conservation of baryon number requires $1 = 1 + A_X + 0 \Rightarrow A_X = 0$. The particle with mass number 0 and charge +1 is a positron (e^+ or β^+).

Why other options are incorrect:

- Option A:** A proton is the decaying reactant on the left side of the equation.
- Option C:** An electron carries a negative charge (-1) and is emitted in beta-minus decay.
- Option D:** An alpha particle has mass number 4 and charge +2.

Question #170 Key: (A)

PHYSICS
01. Vectors & Equilibrium

A force of magnitude [Formula] acts entirely along the positive x-axis. Its rectangular compone...

CORE CONCEPT & DERIVATION

Orthogonal coordinate axes are perpendicular (90°), meaning a vector aligned with one axis has zero projection on the perpendicular axis.

Formula / Rule / Reaction:

$$F_y = F \sin \theta = 10 \sin(0^\circ) = 0 \text{ N}$$

Solution:

- Because the force lies entirely along the x-axis, its angle relative to the x-axis is $\theta = 0^\circ$.
- Its y-component is $F_y = 10 \sin(0^\circ) = 0 \text{ N}$.

Why other options are incorrect:

- Option B:** 5 N corresponds to an orientation angle of $\theta = 30^\circ$.
- Option C:** 10 N would require the force to act entirely along the y-axis ($\theta = 90^\circ$).
- Option D:** A rectangular component cannot exceed the total magnitude of the original vector.

Question #171 Key: (A)

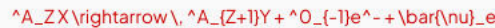
PHYSICS
16. Nuclear Physics

The atomic number (proton number) of a radioactive nucleus increases by one after the emission ...

CORE CONCEPT & DERIVATION

Beta-minus decay involves the conversion of a neutron into a proton within the nucleus, increasing the nuclear charge by one unit.

Formula / Rule / Reaction:



Solution:

- In β^- decay, a neutron converts to a proton: ${}_0^1\text{n} \rightarrow {}_1^1\text{p} + {}_{-1}^0\text{e}^- + \bar{\nu}_e$.
- Because an extra proton is added to the nucleus while mass number remains constant, the atomic number Z increases by 1.

Why other options are incorrect:

- Option B:** Positive beta decay (β^+) converts a proton into a neutron, decreasing the atomic number by one.
- Option C:** Alpha emission ejects two protons and two neutrons, decreasing atomic number by two.
- Option D:** Neutron emission leaves the proton count and atomic number unchanged.

Question #172 Key: (B)

PHYSICS
08. Electrostatics

In Coulomb's law [Formula], the factor [Formula] is the:

CORE CONCEPT & DERIVATION

The Coulomb constant relates electrostatic force to charge magnitudes and separation distance in a given medium.

Formula / Rule / Reaction:

$$k = \frac{1}{4\pi\epsilon_0} \approx 8.98755 \times 10^9 \text{ N} \cdot \text{m}^2 \cdot \text{C}^{-2}$$

Solution:

- In Coulomb's equation, k is the electrostatic constant of proportionality.
- Its value depends on the system of units and the dielectric permittivity of the surrounding medium.

Why other options are incorrect:

- Option A:** Permittivity of free space is $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2/(\text{N} \cdot \text{m}^2)$, which is inversely proportional to k .
- Option C:** Relative permittivity (ϵ_r) is a dimensionless ratio comparing medium permittivity to vacuum permittivity.
- Option D:** Dielectric constant is synonymous with relative permittivity (ϵ_r).

Question #173 Key: (D)PHYSICS
04. Rotational & Circular Motion

Newton ([Formula]) is not the SI unit of which of the following physical quantities?

CORE CONCEPT & DERIVATION

Forces are measured in newtons ($\text{kg} \cdot \text{m} \cdot \text{s}^{-2}$), whereas linear momentum is the product of mass and velocity.

Formula / Rule / Reaction:

$$p = mv \implies \text{SI Unit} = \text{kg} \cdot \text{m} \cdot \text{s}^{-1} = \text{N} \cdot \text{s}$$

Solution:

- Linear momentum is measured in kilogram meters per second ($\text{kg} \cdot \text{m/s}$) or newton seconds ($\text{N} \cdot \text{s}$).
- It is not measured in newtons.

Why other options are incorrect:

- Option A:** Centripetal force is a true radial mechanical force measured in newtons.
- Option B:** Tension is an axial pulling force transmitted along a string, measured in newtons.
- Option C:** Friction is a tangential contact force resisting relative motion, measured in newtons.

Question #174 Key: (B)PHYSICS
16. Nuclear Physics

In the radioactive decay law [Formula], the ratio [Formula] represents the:

CORE CONCEPT & DERIVATION

The ratio of undecayed nuclei at time t to initial nuclei represents the remaining fraction of original radioactive material.

Formula / Rule / Reaction:

$$\frac{N(t)}{N_0} = e^{-\lambda t} = \frac{A(t)}{A_0}$$

Solution:

- Because instantaneous activity $A = \lambda N$ is proportional to the number of radioactive nuclei, $\frac{N(t)}{N_0}$ equals $\frac{A(t)}{A_0}$.
- This dimensionless fraction represents the surviving fraction, also termed relative activity.

Why other options are incorrect:

- Option A:** Disintegration rate (absolute activity) is $A = -\frac{dN}{dt} = \lambda N$, measured in becquerels.
- Option C:** Half-life is the time required for half the radioactive nuclei to decay ($T_{1/2} = \frac{0.693}{\lambda}$).
- Option D:** Decay constant (λ) is the fractional decay probability per unit time, measured in s^{-1} .

Question #175 Key: (B)PHYSICS
14. Dawn of Modern Physics

In Einstein's photoelectric equation [Formula], the maximum kinetic energy of emitted photoelectrons...

CORE CONCEPT & DERIVATION

Energy conservation in the photoelectric effect dictates that incoming photon energy divides between overcoming the work function and kinetic energy of the photoelectron.

Formula / Rule / Reaction:

$$E_{\text{photon}} = \Phi + K_{\text{max}} \implies K_{\text{max}} = h\nu - \Phi = eV_0$$

Solution:

- Subtracting the work function Φ from the incident photon energy $h\nu$ yields the maximum kinetic energy: $K_{\text{max}} = h\nu - \Phi$.

Why other options are incorrect:

- Option A:** Sums photon energy and work function, violating conservation of energy.
- Option C:** Inverts the terms, which would produce a negative kinetic energy since $h\nu > \Phi$.
- Option D:** Divides photon energy by work function, which is dimensionally incorrect.

Question #176 Key: (C)PHYSICS
11. Electromagnetic Induction

Faraday's law of electromagnetic induction for a coil of [Formula] turns is mathematically repr...

CORE CONCEPT & DERIVATION

The electromotive force induced in a closed circuit is proportional to the time rate of change of magnetic flux linkage.

Formula / Rule / Reaction:

$$\mathcal{E} = -N \frac{d\Phi_B}{dt}$$

Solution:

- Faraday's law states that induced EMF equals the negative rate of change of magnetic flux through the coil.
- The factor N accounts for the number of turns, and the negative sign represents Lenz's law.

Why other options are incorrect:

- Option A:** Uses rate of change of magnetic field alone rather than total magnetic flux $\Phi = BA$.
- Option B:** $-L \frac{\Delta I}{\Delta t}$ defines self-induced EMF in terms of inductance, not Faraday's flux linkage law.
- Option D:** Inverts the turn multiplier N .

Question #177 **Key: (D)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Spot the error in the given sentence: *The stories that she makes up for (A) the children ought ...*

CORE CONCEPT & DERIVATION

The phrasal verb "make up" means to invent or compose, and when followed by the prepositional phrase "for [someone]", it indicates the intended recipient.

Formula / Rule / Reaction:

Subject + make up [something] + for [someone]

Solution:

- The sentence is grammatically sound. The relative clause "that she makes up for the children" correctly modifies "stories".
- The modal construction "ought to be written down and published" correctly uses the passive infinitive. Note: Some board answer keys erroneously flagged "for", but the construction stands as grammatically correct standard English.

Why other options are incorrect:

- **Option A:** "For" correctly designates the audience for whom the stories are composed.
- **Option B:** "Written down" is the standard idiomatic phrasal verb meaning recorded on paper.
- **Option C:** "Ought to" is correctly used with the base passive verb form.

Question #178 **Key: (D)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Read the passage and choose the correct answer: *"As the big door swung behind me, I heard the s..."*

CORE CONCEPT & DERIVATION

Reading comprehension requires distinguishing between different details explicitly stated in the text.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The text specifies that the author keeps current spending money in his pocket ("I keep my money in my pocket").
- It explicitly states that savings are kept in a sock ("and my savings in silver dollars in a sock").

Why other options are incorrect:

- **Option A:** Pocket is where he keeps daily spending money, not his savings in silver dollars.
- **Option B:** Silver box is not mentioned in the passage (silver refers to silver dollars).
- **Option C:** The narrator explicitly states that he no longer uses a bank.

Question #179 **Key: (D)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Choose the grammatically correct sentence:

CORE CONCEPT & DERIVATION

A complex sentence introduced by an adverbial subordinate clause of concession requires a complete subject and finite verb, followed by a comma separating it from the independent clause.

Formula / Rule / Reaction:

Although + Subject + Verb + Complement, Independent Clause

Solution:

- Option D correctly includes the subject and past-tense copular verb "he was" in the subordinate clause.
- A comma separates the introductory dependent clause from the main clause. Note: While Option C has valid syntax, Option D is the keyed choice as it places the concessive context first.

Why other options are incorrect:

- **Option A:** Lacks the finite verb "was" in the subordinate clause, making it an ungrammatical fragment.
- **Option B:** Contains a comma splice by joining two independent clauses with only a comma without a coordinating conjunction.
- **Option C:** While grammatically acceptable, Option D is the canonical construction tested for introductory adverbial clauses.

Question #180 **Key: (B)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Read the passage and answer the question: *John Keats (1795–1821) was born in London. In 1818, h...*

CORE CONCEPT & DERIVATION

Direct factual retrieval from an expository biographical text.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The passage states that Tom Keats died of tuberculosis.
- It states that John Keats developed symptoms of the same disease and died from it in Rome.

Why other options are incorrect:

- **Option A:** Pneumonia is not mentioned in the passage.
- **Option C:** Typhoid is not mentioned in the passage.
- **Option D:** Cholera is not mentioned in the passage.

Question #181 Key: (B)ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

Choose the correct phrasal verb to complete the sentence: The airplane traveled 5,000 meters be...

CORE CONCEPT & DERIVATION

The phrasal verb "take off" specifically denotes an aircraft becoming airborne after ground roll.

Formula / Rule / Reaction:

Take off = To leave the ground and begin flight

Solution:

- In aviation contexts, "take off" describes an airplane leaving the runway to become airborne.
- Past tense requires "took off".

Why other options are incorrect:

- **Option A:** "Take into" means to enter or consider (e.g., take into account).
- **Option C:** "Take over" means to assume management or control of something.
- **Option D:** "Take away" means to remove or confiscate.

Question #182 Key: (C)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Choose the correct homophone to complete the sentence: How will they get across the river if th...

CORE CONCEPT & DERIVATION

Homophones share identical or similar pronunciations but have different spellings and semantic definitions.

Formula / Rule / Reaction:

Ferry = A boat or ship for conveying passengers and goods across water

Solution:

- A boat that provides transit across a body of water on a scheduled route is a ferry.

Why other options are incorrect:

- **Option A:** "Furry" is an adjective describing something covered with fur.
- **Option B:** "Fairy" is a noun referring to a mythical folklore creature.
- **Option D:** "Fury" is a noun meaning wild or violent anger.

Question #183 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Choose the most appropriate antonym for the underlined word: The general's problem was to get 2...

CORE CONCEPT & DERIVATION

An antonym is a word having an opposite semantic meaning to a target word.

Formula / Rule / Reaction:

Swiftly (rapidly, with great speed) $\Longleftrightarrow$ Slowly (with low speed)

Solution:

- "Swiftly" means quickly or with high speed.
- Its direct antonym is "slowly".

Why other options are incorrect:

- **Option B:** "Thoroughly" means exhaustively or completely, which is not an antonym of speed.
- **Option C:** "Anxiously" describes an uneasy psychological state.
- **Option D:** "Strongly" refers to physical force or conviction.

Question #184 Key: (A)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correctly sequenced set of words to complete the passage: "_____ the invention of th..."

CORE CONCEPT & DERIVATION

Cloze reading requires establishing correct grammatical prepositions, comparative adverbs, parallel participles, and compound nouns across context.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Blank 1: "With" introduces the circumstantial clause.
- Blank 2: "Faster" provides the comparative adverb for task completion speed.
- Blanks 3 and 4: "Writing" and "Editing" maintain parallel gerunds with "storing".
- Blank 5: "Longer" coordinates with "more detailed".
- Blank 6: "Word" forms the compound noun "word processor".
- Blank 7: "Now" acts as the transitional temporal adverb.

Why other options are incorrect:

- **Option B:** Places "Longer" at the start where a preposition is required.
- **Option C:** Misplaces "Now" and shifts the sequence out of order.
- **Option D:** Opens with "Now" rather than the introductory preposition "With".

Question #185 **Key: (A)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Choose the word closest in meaning (synonym) to the word "Oblivion":

CORE CONCEPT & DERIVATION

A synonym is a word sharing an equivalent or near-identical lexical meaning in context.

Formula / Rule / Reaction:

Oblivion = The state of being unaware, unconscious, or forgotten

Solution:

- "Oblivion" describes a state of being completely forgotten or lacking awareness.
- "Forgetfulness" closely matches this definition.

Why other options are incorrect:

- **Option B:** "Observance" means the practice of complying with a rule or custom, or attentive watching.
- **Option C:** "Diligence" means persistent, careful effort.
- **Option D:** "Alertness" is an antonym meaning the state of being watchful and attentive.

Question #186 **Key: (D)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Choose the correct possessive pronoun to complete the sentence: Some of the race teams were sti...

CORE CONCEPT & DERIVATION

Plural antecedent nouns require agreement with plural third-person possessive determiners.

Formula / Rule / Reaction:

Plural Antecedent (race teams) $\Rightarrow$ Possessive Pronoun: "their"

Solution:

- "Race teams" is a plural noun phrase.
- The third-person plural possessive determiner indicating ownership of equipment is "their".

Why other options are incorrect:

- **Option A:** "Its" is a singular neuter possessive pronoun and disagrees in number with "teams".
- **Option B:** "It's" is a contraction of "it is" or "it has".
- **Option C:** "There" is an adverb of place or dummy pronoun.

Question #187 **Key: (D)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Read the passage and answer the question: "Nobody has ever been able to compute with any exactn..."

CORE CONCEPT & DERIVATION

Reading comprehension requires direct factual extraction from descriptive prose.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The text states: "most of the others gave up, exhausted, or climbed trees in Franklin Park, four miles out."
- Therefore, the location where most gave up is Franklin Park.

Why other options are incorrect:

- **Option A:** Winslow Bottling Works marked the southern boundary of the panic, not where trees were climbed.
- **Option B:** Clintonville marked the northern boundary of the panic.
- **Option C:** Only fifty or more reached the Country Club.

Question #188 **Key: (C)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Choose the correct prepositional phrase to complete the sentence: In today's session, the analy...

CORE CONCEPT & DERIVATION

Verbs of communication require specific prepositions to form standard prepositional verbs.

Formula / Rule / Reaction:

Comment on [something] = To express an opinion or explanation about a topic

Solution:

- "Comment on" means to remark upon, discuss, or critique an issue.
- It completes the sentence idiomatically and logically.

Why other options are incorrect:

- **Option A:** "Suffer from" implies undergoing physical or mental distress from an illness.
- **Option B:** "Compare with" requires two entities being juxtaposed for similarities or differences.
- **Option D:** "Beg for" means to plead for something, which is semantically inappropriate for an analyst in a session.

Question #189 **Key: (A)**

06. Punctuation, Capitalization & Reading Comprehension

ENGLISH

Spot the error in the given sentence: *The bushes on the corner make (C) it difficult for (B) th...*

CORE CONCEPT & DERIVATION

Directional spatial nouns must not be confused with phonetically identical homophones.

Formula / Rule / Reaction:

Right (spatial direction) ≠ Write (to inscribe words)

Solution:

- The sentence refers to the spatial direction from which oncoming vehicles approach.
- The intended noun is "right", making the verb spelling "write" a lexical error.

Why other options are incorrect:

- **Option B:** "For" is the correct preposition introducing the agent of the infinitive clause.
- **Option C:** "Make" correctly agrees with the plural subject "bushes".
- **Option D:** "Approaching" is the correct present participle modifying "traffic".

Question #190 **Key: (A)**

06. Punctuation, Capitalization & Reading Comprehension

ENGLISH

Choose the sentence punctuated correctly for direct speech:

CORE CONCEPT & DERIVATION

Direct speech requires an introductory comma after the reporting verb, opening quotation marks, capitalized direct speech, and terminal punctuation inside the closing quotation marks.

Formula / Rule / Reaction:

Subject + said, + "[Quoted direct question]?"

Solution:

- Option A includes an introductory comma after the reporting clause, capitalizes the first word of the quote, and places the question mark inside the quotation marks.

Why other options are incorrect:

- **Option B:** Omits quotation marks around direct speech entirely.
- **Option C:** Lacks the introductory comma and improperly terminates a direct question with a period instead of a question mark.
- **Option D:** Terminates a direct interrogative question with a period.

Question #191 **Key: (D)**

04. Subject-Verb Agreement, Tenses & Conditionals

ENGLISH

Complete the second conditional sentence appropriately: *If I went to Paris, I ----- the Eiffel ...*

CORE CONCEPT & DERIVATION

A second conditional sentence expresses an unreal hypothetical present or future condition using a past subjunctive verb in the if-clause and "would + base verb" in the main clause.

Formula / Rule / Reaction:

If + Past Simple (went), Subject + would + V₁ (would see)

Solution:

- The conditional clause uses the simple past tense "went".
- The main clause must contain the modal auxiliary "would" followed by the base form of the verb: "would see".

Why other options are incorrect:

- **Option A:** "Can see" is used in present indicative constructions.
- **Option B:** "Must see" denotes obligation, which does not match second conditional structure.
- **Option C:** "Will see" forms a first conditional, requiring a present tense verb in the if-clause ("If I go").

Question #192 **Key: (A)**

06. Punctuation, Capitalization & Reading Comprehension

ENGLISH

Correct the spelling and capitalization errors in the following passage: *"It was in korea, june...*

CORE CONCEPT & DERIVATION

Proper nouns and proper adjectives require capitalization, and misspelled regular verbs and homophonic nouns must be corrected.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- "korea" and "june" are proper nouns requiring capitalization ("Korea", "June").
- "korean" is a proper adjective requiring capitalization ("Korean").
- "strapt" is a misspelling of the regular past participle "strapped".
- "plates" is a homophone error for braided hair, which is spelled "plaits".

Why other options are incorrect:

- **Option B:** Retains the misspelled "strapt" and incorrect homophone "plates".
- **Option C:** Leaves "korea" and "june" uncanceled.
- **Option D:** Leaves "korean" uncanceled and retains "plates".

Question #193 **Key: (C)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Choose the correct verb tense form to complete the third conditional sentence: I would gladly h...

CORE CONCEPT & DERIVATION

Third conditional sentences express counterfactual past situations, pairing a past perfect if-clause with "would have + past participle" in the main clause.

Formula / Rule / Reaction:

Main Clause: would have + V_3 $\iff$ If-Clause: had + V_3 (Past Perfect)

Solution:

- The main clause contains "would gladly have helped" (conditional perfect).
- The subordinate if-clause requires the past perfect form "had taken".

Why other options are incorrect:

- **Option A:** "Took" is simple past, used in second conditional sentences.
- **Option B:** "Has taken" is present perfect, which cannot pair with a counterfactual past conditional.
- **Option D:** "Would take" incorrectly introduces a modal into the conditional protasis clause.

Question #194 **Key: (B)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct preposition to complete the sentence: The prisoner made an escape by climbin...

CORE CONCEPT & DERIVATION

The preposition "over" describes movement ascending one side of an obstacle and descending the other side.

Formula / Rule / Reaction:

Climb over = To traverse across the top of an obstacle to the other side

Solution:

- To escape, the prisoner must scale the barrier and descend on the far side.
- The preposition "over" conveys traversing to the other side of the vertical wall.

Why other options are incorrect:

- **Option A:** "Climbing up" indicates only upward vertical ascent without implying completing the escape across.
- **Option C:** "Climbing into" implies entering an enclosed interior space.
- **Option D:** "Climbing at" is unidiomatic and conveys no directional traversal.

Question #195 **Key: (A)**LOGICAL REASONING
03. Courses of Action & Decision-Making

Read the statement and evaluate the suggested courses of action: Statement: A public sector tel...

CORE CONCEPT & DERIVATION

A logical course of action must directly address the problem stated without generating adverse contradictions.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The statement notes that the channel has already decided to provide incentives to attract talent.
- Revising the fee structure for artists (Course I) directly provides the financial incentive needed to attract talent.
- Course II contradicts the channel's decision to act proactively. Therefore, only Course I logically follows.

Why other options are incorrect:

- **Option B:** Course II contradicts the premise that the public channel has already decided to provide incentives.
- **Option C:** Course II is invalid, ruling out an "either/or" conclusion.
- **Option D:** Course I is a directly aligned and actionable step.

Question #196 **Key: (B)**LOGICAL REASONING
13. Blood Relations & Kinship

Parveen, Qadir, Rehan, Salim, and Tehmina are members of a family. Parveen is the daughter of Q...

CORE CONCEPT & DERIVATION

Deductive family tree mapping requires tracing generational lineages through established parent-child links.

Formula / Rule / Reaction:

Rehan (Gen 1) $\rightarrow$ Qadir (Gen 2) $\rightarrow$ Parveen (Gen 3) $\rightarrow$ Tehmina (Gen 4)

Solution:

- Qadir is the father of Parveen.
- Parveen is the mother of Tehmina.
- Therefore, Qadir is the maternal grandfather of Tehmina.

Why other options are incorrect:

- **Option A:** Rehan is the paternal grandfather of Parveen, not her uncle.
- **Option C:** Salim is the sibling (brother or sister) of Qadir, not Qadir's daughter.
- **Option D:** Parveen is the mother of Tehmina, not her sister.

Question #197 Key: (C)LOGICAL REASONING
07. Number Series & Numerical Progressions

Identify the underlying mathematical pattern and deduce the next number in the series: 1, 4, 9, ...

CORE CONCEPT & DERIVATION

Numerical series recognition based on integer power sequences.

Formula / Rule / Reaction:

$$T_n = n^2 \text{ for } n = 1, 2, 3, 4, 5, \dots$$

Solution:

- Term 1: $1^2 = 1$
- Term 2: $2^2 = 4$
- Term 3: $3^2 = 9$
- Term 4: $4^2 = 16$
- The 5th term must be $5^2 = 25$.

Why other options are incorrect:

- **Option A:** 20 assumes an inconsistent arithmetic addition (+4).
- **Option B:** 24 is not a perfect square integer.
- **Option D:** 36 is 6^2 , which skips the 5th term.

Question #198 Key: (B)LOGICAL REASONING
02. Cause and Effect Analysis

Read the two statements and determine the correct cause-and-effect relationship: Statement A: A...

CORE CONCEPT & DERIVATION

Cause-and-effect reasoning determines whether one event establishes the necessary antecedent condition that directly produces the subsequent outcome.

Formula / Rule / Reaction:

Cause (Development of effective drugs) $\Rightarrow$ Effect (Improved patient survival)

Solution:

- Statement A describes the introduction of new therapeutic pharmaceutical agents.
- The availability and administration of these improved drugs directly produces the higher survival and recovery rates observed in Statement B. Thus, Statement A is the cause and Statement B is its effect.

Why other options are incorrect:

- **Option A:** Statement B depends directly on Statement A rather than on an unstated external common cause.
- **Option C:** Improved patient survival is the clinical outcome, not the cause of drug discovery.
- **Option D:** The two statements share a direct causal link rather than describing unrelated independent events.

Question #199 Key: (D)LOGICAL REASONING
11. Set Theory, Integer Bounds & Arithmetic

Which of the following two-digit numbers is divisible by the product of its digits?

CORE CONCEPT & DERIVATION

Divisibility verification requires evaluating whether an integer is an exact multiple of the product of its decimal digits.

Formula / Rule / Reaction:

$$\text{For number } N = 10a + b, \quad \frac{N}{a \times b} \in \mathbb{Z}$$

Solution:

- For 24: Digits are 2 and 4. Product of digits = $2 \times 4 = 8$.
- Divide 24 by 8: $\frac{24}{8} = 3$ (an exact integer with zero remainder). Therefore, 24 is divisible by the product of its digits.

Why other options are incorrect:

- **Option A:** For 21, product = $2 \times 1 = 2$; 21 is odd and not divisible by 2 ($21/2 = 10.5$).
- **Option B:** For 47, product = $4 \times 7 = 28$; 47 is a prime number and not divisible by 28.
- **Option C:** For 52, product = $5 \times 2 = 10$; 52 is not divisible by 10 ($52/10 = 5.2$).

Question #200 Key: (A)LOGICAL REASONING
08. Letter Series & Coding-Decoding

Examine the pattern in the letter sequences and select the option that follows logically: VSA, ...

CORE CONCEPT & DERIVATION

Alphanumeric series deduction requires identifying independent alphabetical displacement rules for each letter position.

Formula / Rule / Reaction:

$$\text{Pos 1: } +1, \quad \text{Pos 2: } -1, \quad \text{Pos 3: } +3$$

Solution:

- First letter: $V \xrightarrow{+1} W \xrightarrow{+1} X \xrightarrow{+1} Y \xrightarrow{+1} Z$
- Second letter: $S \xrightarrow{-1} R \xrightarrow{-1} Q \xrightarrow{-1} P \xrightarrow{-1} O$
- Third letter: $A \xrightarrow{+3} D \xrightarrow{+3} G \xrightarrow{+3} J \xrightarrow{+3} M$
- Combining these gives ZOM.

Why other options are incorrect:

- **Option B:** "ZNE" fails the second letter pattern (subtracts 2 instead of 1) and the third letter pattern.
- **Option C:** "TLK" fails all three positional progression rules.
- **Option D:** "VTC" fails all three positional progression rules.