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KMU PESHAWAR

KMU Peshawar MDCAT 2022 Official Paper

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

📄 Official Admitting Board: Khyber Medical University Peshawar 📄 Archive Code: BEAMBE-FLP-KMU-2022 ⌚ Duration: 200 Minutes (3h 20m)

200

TOTAL QUESTIONS

200m

OFFICIAL DURATION

+1 / 0.00

ZERO NEGATIVE MARKING

200

MAXIMUM MARKS

📄 EXAMINATION BLUEPRINT & SUBJECT WEIGHTAGE

Biology**68 MCQs**

34.0% weight

Chemistry**54 MCQs**

27.0% weight

Physics**54 MCQs**

27.0% weight

English**18 MCQs**

9.0% weight

Logical Reasoning**6 MCQs**

3.0% weight

BIO SECTION: BIOLOGY

Questions 1 to 68 (68 MCQs)

Q1. BIO

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

- (A) They do not respire
- (B) They do not excrete
- (C) They do not have the ability to reproduce
- (D) They can be crystallised

Q2. BIO

In 1935, W. M. Stanley prepared an extract of:

- (A) Tobacco mosaic virus (TMV)
- (B) Human immunodeficiency virus (HIV)
- (C) Flu virus
- (D) Polio virus

Q3. BIO

Human immunodeficiency virus (HIV) particles are surrounded by a coat known as the viral envelope or membrane made up of:

- (A) Glycoprotein
- (B) Glycolipid
- (C) Lipoprotein
- (D) Sulpholipid

Q4. BIO

The word hepatitis means inflammation of the:

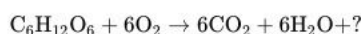
- (A) Pancreas
- (B) Liver
- (C) Spleen
- (D) Gall bladder

Q5. BIO

The resting membrane potential of a typical neuron is measured at about:

- (A) -30 millivolts
- (B) -50 millivolts
- (C) -70 millivolts
- (D) -100 millivolts

Q6. BIO

In aerobic respiration, the glucose molecule is completely broken down into carbon dioxide (CO_2), water (H_2O), and energy:

- (A) 2 ATP
- (B) 4 ATP
- (C) 34 ATP
- (D) 36 ATP

Q7. BIO

The four types of fundamental biological molecules present in protoplasm are carbohydrates, proteins, lipids, and:

- (A) Enzymes
- (B) Hormones
- (C) Nucleic Acids
- (D) Alkaloids

Q8. BIO

Ribose is a pentose sugar (5 carbon) that contains an:

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

Q9. BIO

Proteins are macromolecules formed of units known as amino acids. The amino acid in which the variable group (R) is represented by a hydrogen atom is:

- (A) Lysine
- (B) Phenylalanine
- (C) Glycine
- (D) Alanine

Q10. BIO

The type of lipids which do not contain fatty acids are:

- (A) Phospholipids
- (B) Waxes
- (C) Steroids
- (D) Acylglycerols

Q11. BIO

In which part of the chloroplast does the fixation of carbon dioxide result in the formation of sugars?

- (A) Grana
- (B) Stroma
- (C) Intergranum
- (D) Outer membrane of chloroplast

Q12. BIO

The colloidal mixture of ions, organic, and inorganic salts present in the nucleus is called:

- (A) Nuclear membrane
- (B) Nucleolus
- (C) Nucleoplasm
- (D) Chromosome

Q13. BIO

Those nerves that originate from or lead directly to the brain are called cranial nerves. There are _____ pairs of cranial nerves in humans.

- (A) 6
- (B) 12
- (C) 14
- (D) 31

Q14. BIO

The hormone that triggers the release (let-down) of milk in lactating women is:

- (A) Growth hormone
- (B) Antidiuretic hormone
- (C) Oxytocin
- (D) Follicle stimulating hormone

Q15. BIO

The group of organisms possessing a single-celled body that performs all the vital activities of life are called:

- (A) Protozoa
- (B) Parazoa
- (C) Metazoa
- (D) Nanozoa

Q16. BIO

The word 'Annelida' is of Latin origin; 'annellus' means:

- (A) Little ring
- (B) Segmented body
- (C) Thread
- (D) Hollow

Q17. BIO

Most of the coenzymes are derivatives of:

- (A) Lipids
- (B) Vitamins
- (C) Steroids
- (D) Waxes

Q18. BIO

Genetic drift is the change in the allele frequency of a population due to:

- (A) Random chance
- (B) Non-random mating
- (C) Natural selection
- (D) Artificial selection

Q19. BIO

The basis of Lamarck's theory of evolution is:

- (A) Survival of the fittest
- (B) Selection by nature
- (C) Inheritance of acquired characters
- (D) Theory of special creation

Q20. BIO

Which one of the following parts of the human respiratory system forms the actual gas exchange surface?

- (A) Trachea
- (B) Larynx
- (C) Bronchi
- (D) Alveoli

Q21. BIO

The average adult human has a total lung capacity of approximately:

- (A) 2 litres
- (B) 5 litres
- (C) 9 litres
- (D) 12 litres

Q22. BIO

The process of spermatogenesis (formation of sperm) takes place in which part of the male reproductive system?

- (A) Urethra
- (B) Epididymis
- (C) Oviduct
- (D) Seminiferous tubules

Q23. BIO

Which one of the following cells possesses a haploid (n) number of chromosomes?

- (A) Sperm cell
- (B) Mesophyll cell
- (C) Skin cell
- (D) Muscular cell

Q24. BIO

Those joints in which the articulating bones are separated by a fluid-containing joint cavity are called:

- (A) Fibrous joints
- (B) Cartilaginous joints
- (C) Synovial joints
- (D) Immovable joints

Q25. BIO

The joints present in the human elbow and knee are examples of which type of joint?

- (A) Immovable joint
- (B) Slightly movable joint
- (C) Hinge joint
- (D) Ball and socket joint

Q26. BIO

A man of blood group A marries a woman of blood group B, and they have one child. Which one of the following statements about the child's blood group is correct?

- (A) It could be group A only.
- (B) It could be group AB only.
- (C) It could be group A or group B only.
- (D) It could be any of the groups A, B, AB, and O.

Q27. BIO

Red-green colour blindness is a recessive sex-linked trait that renders individuals unable to distinguish shades of red or green, and both typically appear as:

- (A) Red
- (B) Green
- (C) Grey
- (D) Yellow

Q28. BIO

The statement 'the membrane is like a sea of lipids in which proteins are floating' represents the:

- (A) Gorter & Grendel Model
- (B) J. F. Danielli & Davson Model
- (C) Robertson Model
- (D) S. J. Singer & Nicolson Model

Q29. BIO

Detoxification of drugs and harmful chemicals is a major function of the:

- (A) Golgi bodies
- (B) Mitochondria
- (C) Rough Endoplasmic Reticulum
- (D) Smooth Endoplasmic Reticulum

Q30. BIO

Chloroplasts contain:

- (A) Proteins only
- (B) Ribosomes only
- (C) Small circular DNA only
- (D) Proteins, ribosomes, and small circular DNA

Q31. BIO

Mitochondria were first observed as intracellular granules in:

- (A) White blood cells
- (B) Red blood cells
- (C) Muscle cells
- (D) Liver cells

Q32. BIO

Haemoglobin is classified chemically as a:

- (A) Carbohydrate
- (B) Protein
- (C) Nucleic acid
- (D) Enzyme

Q33. BIO

Glycerol is an alcohol containing how many carbon atoms?

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

Q34. BIO

Enzymes are almost exclusively _____ in chemical nature.

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

Q35. BIO

The range of wavelengths that constitutes the visible light spectrum is approximately:

- (A) 300 to 650 nm
- (B) 350 to 700 nm
- (C) 380 to 750 nm
- (D) 430 to 790 nm

Q36. BIO

Which scientist hypothesized that plants split water to release oxygen as a by-product during photosynthesis?

- (A) Van Niel
- (B) Lysenko
- (C) Calvin
- (D) Krebs

Q37. BIO

The Calvin cycle operates in how many primary stages?

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

Q38. BIO

Which of the following pairs of human diseases are both caused by viruses?

- (A) Syphilis and Tuberculosis (TB)
- (B) AIDS and Typhoid
- (C) Measles and Mumps
- (D) Tetanus and Cholera

Q39. BIO

The terminal portion of the human male reproductive duct system that conveys semen to the exterior is the:

- (A) Vasa efferentia
- (B) Vas deferens
- (C) Urethra
- (D) Epididymis

Q40. BIO

The cell wall of true bacteria (eubacteria) is primarily composed of:

- (A) Chitin
- (B) Cellulose
- (C) Peptidoglycan
- (D) Pectin

Q41. BIO

Which one of the following is not a carnivorous (insectivorous) plant?

- (A) Pitcher plant
- (B) Sundew
- (C) Butterwort
- (D) Money plant

Q42. BIO

All of the following are characteristics of cartilage except:

- (A) It is a type of connective tissue
- (B) The precursor cells are chondrocytes
- (C) It contains blood vessels
- (D) It heals very slowly

Q43. BIO

Which one of the following is not a recognized feature or classification of arthritis?

- (A) Inflammation of a joint
- (B) An autoimmune disease
- (C) The leading cause of disability in patients over the age of 65
- (D) Inflammation of a nerve

Q44. BIO

A clear genetic exception to Mendel's Law of Independent Assortment is:

- (A) Linkage
- (B) Dominance
- (C) Purity of gametes
- (D) Segregation

Q45. BIO

The hollow, elongated transverse invaginations formed when the sarcolemma of a muscle fibre penetrates deep into the interior of the cell are known as:

- (A) A tubules
- (B) M tubules
- (C) T tubules
- (D) Z tubules

Q46. BIO

The type of neuron that conducts nerve impulses from sensory receptors and peripheral tissues to the spinal cord or brain is a/an:

- (A) Sensory neuron
- (B) Motor neuron
- (C) Intermediate neuron
- (D) Associative neuron

Q47. BIO

Hormones are biologically defined as:

- (A) Genetic messengers
- (B) Physical messengers
- (C) Chemical messengers
- (D) Biological catalysts

Q48. BIO

Which lobe of the pituitary gland produces and secretes tropic hormones that control multiple other endocrine glands, earning it the title 'master gland'?

- (A) Anterior lobe
- (B) Posterior lobe
- (C) Intermediate lobe
- (D) Anterior-posterior lobe

Q49. BIO

Which hormone acts directly on target tissues to lower blood glucose levels?

- (A) Glucagon
- (B) Cortisol
- (C) Insulin
- (D) Epinephrine

Q50. BIO

If a homozygous white-eyed female *Drosophila* is crossed with a wild-type red-eyed male, what is the probability that their male offspring will have white eyes?

- (A) 0%
- (B) 25%
- (C) 50%
- (D) 100%

Q51. BIO

Who coined and originally used the evolutionary phrase 'survival of the fittest'?

- (A) Lamarck
- (B) Darwin
- (C) Herbert Spencer
- (D) Aristotle

Q52. BIO

The raw material that is acted upon by natural selection to enable evolutionary adaptation is/are:

- (A) Variation only
- (B) Mutation only
- (C) Similarity only
- (D) Variation and mutation

Q53. BIO

Archaeopteryx is a renowned transitional fossil that possesses anatomical characteristics of both:

- (A) Fishes and Amphibians
- (B) Amphibians and Reptiles
- (C) Reptiles and Birds
- (D) Birds and Mammals

Q54. BIO

Who proposed the evolutionary concept that an organism can pass modifications acquired during its lifetime on to its offspring?

- (A) Lamarck
- (B) Darwin
- (C) Malthus
- (D) Aristotle

Q55. BIO

Cytotoxic T-lymphocytes (CD8+ T-cells) primarily defend the body by:

- (A) Directly killing invaders and infected cells
- (B) Aiding B-cells in antibody production
- (C) Differentiating into plasma cells
- (D) Suppressing active T-cell proliferation

Q56. BIO

A bacterial cell with a single flagellum located at one pole is classified morphologically as:

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

Q57. BIO

The genetic material of the Human Immunodeficiency Virus (HIV) consists of:

- (A) Complementary DNA (cDNA)
- (B) Double-stranded DNA
- (C) Single-stranded RNA
- (D) Ribosomal RNA (rRNA)

Q58. BIO

The human hip joint and shoulder joint are anatomical examples of:

- (A) Cartilaginous joints
- (B) Fibrous joints
- (C) Hinge joints
- (D) Ball and socket joints

Q59. BIO

The specific physical position occupied by a gene on a chromosome is termed its:

- (A) Locus
- (B) Function
- (C) Start point
- (D) End point

Q60. BIO

Carotenoid accessory pigments primarily absorb light in which region of the visible spectrum?

- (A) 400 to 500 nm
- (B) 530 to 700 nm
- (C) 620 to 700 nm
- (D) 500 to 600 nm

Q61. BIO

The inner epithelial cells lining the endoderm (gastrodermis) of Coelenterates are primarily specialized for:

- (A) Excretion
- (B) Digestion
- (C) Defense
- (D) Respiration

Q62. BIO

Viruses are not classified on the basis of which of the following characteristics?

- (A) Capsid morphology
- (B) Host specificity
- (C) Cell membrane structure
- (D) Envelope presence or absence

Q63. BIO

An additional protective covering surrounding the cell wall of certain pathogenic bacteria that impedes host phagocytosis and facilitates biofilm formation is the:

- (A) Capsule
- (B) Slime layer
- (C) Cell membrane
- (D) Endospore

Q64. BIO

The protective protein shell that encloses the viral nucleic acid genome is called the:

- (A) Capsid
- (B) DNA sheath
- (C) Bacteriophage
- (D) Viroid

Q65. BIO

In the non-cyclic electron transport (Z-scheme) of the photosynthetic light reactions, an absorbed photon causes an electron deficit of how many electrons in the reaction center chlorophyll of Photosystem II?

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

Q66. BIO

What is the total number of carbon atoms present in one molecule of pyruvic acid (pyruvate)?

- (A) 8
- (B) 2
- (C) 3
- (D) 4

Q67. BIO

Enzymatic hydrolysis of one molecule of the disaccharide sucrose yields:

- (A) Lactose and Glucose
- (B) Lactose and Fructose
- (C) Glucose and Fructose
- (D) Glucose and Galactose

Q68. BIO

The quantity of thermal energy required to convert one gram of a liquid into vapour at its normal boiling point without a change in temperature is called its:

- (A) Heat of vaporization
- (B) Specific heat capacity
- (C) Heat of ionization
- (D) Polarity of water

CHEM SECTION: CHEMISTRY

Questions 69 to 122 (54 MCQs)

Q69. CHEM

Which of the following contains the same number of molecules as 22 grams of carbon dioxide (CO_2)?

- (A) 9 g of water
- (B) 2 g of hydrogen gas
- (C) 32 g of oxygen gas
- (D) 71 g of chlorine gas

Q70. CHEM

The molecular mass of an organic compound is 60, and its empirical formula is CH_2O . What is its molecular formula?

- (A) $\text{C}_6\text{H}_{12}\text{O}_6$
- (B) $\text{C}_2\text{H}_4\text{O}_2$
- (C) $\text{C}_2\text{H}_6\text{O}_2$
- (D) $\text{C}_2\text{H}_8\text{O}_2$

Q71. CHEM

According to Planck's quantum theory, the greater the wavelength (λ) associated with a photon:

- (A) The greater is its energy
- (B) The smaller is its energy
- (C) Its energy will be variable and non-quantized
- (D) Its energy will remain constant

Q72. CHEM

Identify the compound in which the chemical bonds are formed by the overlapping of *sp* and *p* atomic orbitals:

- (A) BeCl_2
- (B) BF_3
- (C) H_2O
- (D) NH_3

Q73. CHEM

Which of the following second-period elements has the highest first ionization energy?

- (A) O
- (B) C
- (C) N
- (D) Be

Q74. CHEM

Which of the following real gases shows the most marked deviation from ideal gas behavior under moderate temperatures and pressures?

- (A) CO_2
- (B) He
- (C) H_2
- (D) N_2

Q75. CHEM

The exceptionally low acidic strength of hydrofluoric acid (HF) compared to other hydrohalic acids is primarily due to:

- (A) The strong polar bond between H and F
- (B) The smaller atomic size of fluorine
- (C) Strong intermolecular hydrogen bonding and high bond dissociation energy
- (D) The high electronegativity of fluorine

Q76. CHEM

Which of the following compounds has the lowest normal boiling point?

- (A) Water (H_2O)
- (B) Ethanol ($\text{C}_2\text{H}_5\text{OH}$)
- (C) Hydrogen sulphide (H_2S)
- (D) Acetic acid (CH_3COOH)

Q77. CHEM

A domestic pressure cooker significantly reduces the time required to cook food because:

- (A) A large quantity of heat is trapped inside
- (B) Heat is distributed more evenly
- (C) The boiling point of water increases under elevated pressure
- (D) The higher vapor pressure mechanically softens food

Q78. CHEM

Which of the following ionic compounds has the highest value of lattice energy?

- (A) NaF
- (B) LiCl
- (C) NaI
- (D) KI

Q79. CHEM

Which of the following is classified as a polar molecular crystalline solid?

- (A) Ice
- (B) Iodine (I_2)
- (C) Copper (Cu)
- (D) Phosphorus (P_4)

Q80. CHEM

Which of the following divalent transition metal ions typically forms the most thermodynamically stable complex compounds?

- (A) Cu^{2+}
- (B) Ni^{2+}
- (C) Fe^{2+}
- (D) Mn^{2+}

Q81. CHEM

All of the following chemical compounds are classified as organic except:

- (A) KOCN
- (B) $\text{C}_6\text{H}_5\text{OH}$
- (C) $\text{CH}_3\text{COOCH}_3$
- (D) CH_3OH

Q82. CHEM

Structural or stereochemical isomers of a chemical substance must always possess the same:

- (A) Molecular mass
- (B) Chemical properties
- (C) Structural formula
- (D) Functional group

Q83. CHEM

Which of the following cycloalkanes possesses the highest normal boiling point?

- (A) Cyclohexane
- (B) Cycloheptane
- (C) Cyclopentane
- (D) Cyclobutane

Q84. CHEM

Propyne reacts with aqueous sulfuric acid in the presence of mercuric sulfate (HgSO_4) catalyst to form:

- (A) Acetone
- (B) 1-propanol
- (C) 2-propanol
- (D) Acetaldehyde

Q85. CHEM

The active electrophile responsible for the electrophilic aromatic substitution in the nitration of benzene is:

- (A) NO_2^+
- (B) NO_2^-
- (C) NO^+
- (D) HNO_2^+

Q86. CHEM

Which of the following alkyl halides will undergo the fastest $\text{S}_{\text{N}}2$ nucleophilic substitution reaction with aqueous sodium hydroxide?

- (A) Methyl bromide
- (B) Ethyl bromide
- (C) Isopropyl bromide
- (D) Tert-butyl bromide

Q87. CHEM

Which of the following alkyl halides has the highest normal boiling point?

- (A) n-butyl iodide
- (B) isobutyl iodide
- (C) isopropyl bromide
- (D) n-propyl bromide

Q88. CHEM

Which of the following factors does not affect the rate of an $\text{S}_{\text{N}}1$ nucleophilic substitution reaction?

- (A) Nature and polarity of the solvent
- (B) Stability of the carbocation intermediate
- (C) Nature and concentration of the nucleophile
- (D) Structure of the alkyl substrate

Q89. CHEM

Which of the following hydroxyl-containing organic compounds exhibits the lowest acidic strength (highest $\text{p}K_{\text{a}}$)?

- (A) Phenol
- (B) p-Nitrophenol
- (C) Ethanol
- (D) p-Chlorophenol

Q90. CHEM

The buffering capacity of an aqueous buffer solution reaches its maximum efficiency when:

- (A) Both components are present in very dilute concentrations
- (B) The conjugate acid and conjugate base have equal, low concentrations
- (C) The buffer ratio $[\text{Base}]/[\text{Acid}]$ exceeds 10
- (D) The conjugate components have high and equal molar concentrations

Q91. CHEM

If an ionic salt has a relatively large solubility product constant (K_{sp}) in water at room temperature, it indicates that the salt is:

- (A) More soluble
- (B) Less soluble
- (C) Moderately insoluble
- (D) Completely insoluble

Q92. CHEM

If the specific rate constant (k) of a chemical reaction has the units $\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$, what is the overall order of the reaction?

- (A) First order
- (B) Second order
- (C) Zero order
- (D) Third order

Q93. CHEM

A thermodynamic system that can freely exchange both energy and matter with its surroundings is called a/an:

- (A) Isolated system
- (B) Closed system
- (C) Open system
- (D) Adiabatic system

Q94. CHEM

The total sum of all translational, rotational, vibrational kinetic energies, and intermolecular potential energies of all constituent particles in a substance is called its:

- (A) Specific heat
- (B) Heat capacity
- (C) Latent heat
- (D) Internal energy

Q95. CHEM

Which of the following chemical elements exhibits the same fixed oxidation state in all of its known neutral and ionic compounds?

- (A) Beryllium
- (B) Chlorine
- (C) Nitrogen
- (D) Bromine

Q96. CHEM

In any functioning galvanic (voltaic) electrochemical cell, the cathode always has a standard reduction potential that is:

- (A) Less than that of the anode
- (B) More positive than that of the anode
- (C) Identical to that of the anode
- (D) Exactly zero

Q97. CHEM

When an isolated neutral atom gains one or more electrons to form an anion, its radius changes such that the ionic radius is:

- (A) Smaller than the covalent radius
- (B) Smaller than the parent atomic radius
- (C) Equal to the parent atomic radius
- (D) Greater than the parent atomic radius

Q98. CHEM

What is the elemental chemical composition of the non-ferrous alloy known as German silver?

- (A) Cu + Zn + Ni
- (B) Cu + Ag + Ni
- (C) Cu + Sn + Zn + Pb
- (D) Al + Cu + Mg + Mn

Q99. CHEM

A first-order chemical reaction proceeds with a rate of $0.6 \text{ mol} \cdot \text{dm}^{-3} \text{ s}^{-1}$ when the reactant concentration is $1.0 \text{ mol} \cdot \text{dm}^{-3}$. What is the specific rate constant (k) of this reaction?

- (A) 1.0 s^{-1}
- (B) 0.3 s^{-1}
- (C) 0.6 s^{-1}
- (D) 0.9 s^{-1}

Q100. CHEM

What type of reaction mechanism takes place when phenol is treated with dilute nitric acid (HNO_3) at room temperature?

- (A) Electrophilic addition
- (B) Electrophilic substitution
- (C) Nucleophilic substitution
- (D) Elimination

Q101. CHEM

Acetone reacts with hydrogen cyanide (HCN) to form acetone cyanohydrin. This reaction is an example of:

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

Q102. CHEM

Benedict's solution is chemically composed of a combination of:

- (A) Sodium carbonate, sodium citrate, and copper(II) sulfate pentahydrate
- (B) $\text{Cu}(\text{OH})_2$, NaOH, and tartaric acid
- (C) $[\text{Ag}(\text{NH}_3)_2]\text{OH}$, NaOH, and H_2SO_4
- (D) NaCl, NaOH, and citric acid

Q103. CHEM

Which of the following statements is false regarding the acidic strength of acetic acid?

- (A) Acetic acid is a stronger acid than monochloroacetic acid.
- (B) Acetic acid is a stronger acid than propionic acid.
- (C) Acetic acid is a weaker acid than trichloroacetic acid.
- (D) Acetic acid is a weaker acid than formic acid.

Q104. CHEM

The linear sequence and order of amino acid units along a polypeptide chain is called its:

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

Q105. CHEM

The quantity of a chemical product that is actually obtained from a chemical reaction carried out in a laboratory experiment is called the:

- (A) Mole
- (B) Actual yield
- (C) Theoretical yield
- (D) Percent yield

Q106. CHEM

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

- (A) Trigonal bipyramidal
- (B) Trigonal pyramidal
- (C) Trigonal planar
- (D) Square planar

Q107. CHEM

The thermal decomposition of dinitrogen pentoxide in the gaseous state follows which reaction order?



- (A) First order
- (B) Second order
- (C) Fractional order
- (D) Third order

Q108. CHEM

The temperature above which two partially miscible conjugate solutions merge into one another to form a single homogeneous phase is called the:

- (A) Critical solution temperature
- (B) Critical solution point
- (C) Absolute solution temperature
- (D) Absolute solution point

Q109. CHEM

In which of the following molecular substances is intermolecular hydrogen bonding completely absent?

- (A) H_2O
- (B) HF
- (C) CH_4
- (D) NH_3

Q110. CHEM

A laboratory distillation carried out under reduced atmospheric pressure to purify heat-sensitive organic compounds below their normal decomposition temperatures is called:

- (A) Steam distillation
- (B) Simple distillation
- (C) Fractional distillation
- (D) Vacuum distillation

Q111. CHEM

Which one of the following pairs of crystalline chemical compounds is not isomorphous in nature?

- (A) NaF and MgO
- (B) KNO_3 and NaNO_3
- (C) ZnO and CdS
- (D) AgNO_3 and KNO_3

Q112. CHEM

The numerical value of the solubility product constant (K_{sp}) of a sparingly soluble salt depends solely on:

- (A) Temperature
- (B) Volume of solvent
- (C) External pressure
- (D) Presence of a catalyst

Q113. CHEM

All typical alkaline earth metal oxides are white crystalline solids with basic properties except the amphoteric oxide of:

- (A) Beryllium
- (B) Magnesium
- (C) Calcium
- (D) Strontium

Q114. CHEM

The optical activity (angle of optical rotation) of a chiral chemical compound in solution is measured using a:

- (A) Hydrometer
- (B) Barometer
- (C) Calorimeter
- (D) Polarimeter

Q115. CHEM

The structural isomerism in which constitutional isomers exist in a state of dynamic equilibrium with one another through the migration of an atom or group is termed:

- (A) Chain isomerism
- (B) Position isomerism
- (C) Metamerism
- (D) Tautomerism

Q116. CHEM

The aromatic hydrocarbon isopropylbenzene is commonly known in industrial organic chemistry as:

- (A) Cumene
- (B) Xylene
- (C) Toluene
- (D) Cresol

Q117. CHEM

The first ionization energy of aluminum (Al, $Z = 13$) is lower than that of magnesium (Mg, $Z = 12$). This anomaly is primarily due to:

- (A) The outermost electron of Al residing in a higher-energy, shielded $3p$ orbital
- (B) Al being less metallic than Mg
- (C) Mg possessing a greater nuclear charge than Al
- (D) The ionization energy decreasing uniformly across period 3

Q118. CHEM

Which of the following complex iron cyanide salts is responsible for the deep Prussian blue color?

- (A) Ferric hexacyanoferrate(II)
- (B) Iron(III) hexacyanoferrate(II)
- (C) Sodium hexacyanoferrate(III)
- (D) Both (A) and (B)

Q119. CHEM

Which of the following organic compounds is the strongest Lewis base?

- (A) Phenol
- (B) Aniline
- (C) Pyridine
- (D) Both (A) and (B) have equal strength

Q120. CHEM

A spectral photon emitted in which of the following series of the hydrogen atomic spectrum will possess the largest wavelength?

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

Q121. CHEM

Which of the following chemical elements has the highest second ionization energy?

- (A) Potassium (K)
- (B) Calcium (Ca)
- (C) Chlorine (Cl)
- (D) Bismuth (Bi)

Q122. CHEM

The more positive (stronger) the standard reduction potential of a chemical species, the more difficult it is to:

- (A) Reduce the compound
- (B) Oxidize the compound
- (C) Electrolyze the compound
- (D) Neither reduce nor oxidize the compound

PHY SECTION: PHYSICS

Questions 123 to 176 (54 MCQs)

Q123. PHY

A body travels a displacement of 10 m towards the North and then returns to its initial starting point by traveling 10 m towards the South. Its total resultant displacement is:

- (A) 20 m North
- (B) 10 m South
- (C) 0 m along North-South
- (D) 0 m

Q124. PHY

The SI unit of kinetic energy is identical to the unit of which of the following physical quantities?

- (A) Momentum
- (B) Velocity
- (C) Force
- (D) Work

Q125. PHY

Which of the following physical quantities is not a vector quantity?

- (A) Angular displacement
- (B) Impulse
- (C) Moment of inertia
- (D) Linear momentum

Q126. PHY

According to Newton's first law of motion, which kinematic quantity remains constant for a body in the absence of a net external force?

- (A) Velocity
- (B) Angular displacement
- (C) Amplitude
- (D) Work done

Q127. PHY

The law of inertia (Newton's first law of motion) satisfies the physical condition for:

- (A) Equilibrium
- (B) Variable force
- (C) Force in contact
- (D) Conservation of mass

Q128. PHY

When five times the linear momentum of a moving body is numerically equal to its kinetic energy, its velocity is:

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

Q129. PHY

When the angular speed (ω) of a body moving in a circular path of fixed radius is doubled, its centripetal acceleration becomes:

- (A) Doubled
- (B) Three times
- (C) Four times
- (D) Unchanged

Q130. PHY

A projectile is launched from ground level into the air. Neglecting air resistance, the magnitude of its velocity (speed) is maximum at:

- (A) The point of projection
- (B) The highest point of the trajectory
- (C) A point halfway between launch and maximum height
- (D) All points along the trajectory equally

Q131. PHY

The mathematical equation defining the translational kinetic energy of a body of mass m moving with velocity v is:

- (A) $K.E = mv^2$
- (B) $K.E = \frac{1}{2}mv^2$
- (C) $K.E = \frac{mgh}{2}$
- (D) $K.E = mgh$

Q132. PHY

Two bodies A and B with initial temperatures $T_A = 100^\circ\text{C}$ and $T_B = 0^\circ\text{C}$ are brought into thermal contact inside an isolated system. Which of the following temperature pairs is possible when they reach thermal equilibrium?

- (A) $T_A = 0^\circ\text{C}$, $T_B = 100^\circ\text{C}$
- (B) $T_A = 60^\circ\text{C}$, $T_B = 50^\circ\text{C}$
- (C) $T_A = 45^\circ\text{C}$, $T_B = 45^\circ\text{C}$
- (D) $T_A = 60^\circ\text{C}$, $T_B = 40^\circ\text{C}$

Q133. PHY

In an isolated thermodynamic system, which of the following statements correctly describes the exchange of energy and matter across its boundary?

- (A) No heat transfers, but mass can transfer
- (B) Neither heat nor mass is transferred to the environment
- (C) No mechanical work transfers, but heat can transfer
- (D) No mass transfers, but heat can transfer

Q134. PHY

The electrical potential energy (U) stored in a capacitor of capacitance C charged to a potential difference V is given by:

- (A) $U = \frac{1}{2}QV^2$
- (B) $U = \frac{1}{2}CV^2$
- (C) $U = \frac{1}{2}QC^2$
- (D) $U = \frac{Q}{2V}$

Q135. PHY

Two point charges, $Q_1 = +3\mu\text{C}$ and $Q_2 = -1\mu\text{C}$, are separated by a distance of 100 cm. The net electric potential is zero at a point along the line joining them at a distance of:

- (A) 25 cm from Q_2
- (B) 75 cm from Q_2
- (C) 50 cm from Q_1
- (D) 33.3 cm from Q_1

Q136. PHY

Magnetic lines of force (magnetic field lines) are correctly described as:

- (A) Imaginary lines used to represent an actual magnetic field
- (B) Actual physical lines that represent an actual magnetic field
- (C) Actual physical lines that represent an imaginary magnetic field
- (D) Imaginary lines that represent an imaginary magnetic field

Q137. PHY

A potential divider circuit operates fundamentally on the principle that:

- (A) Electric current is divided across parallel branches
- (B) EMF of the source is divided by internal resistance
- (C) Total electrical resistance is tapped and divided in series
- (D) The number of conduction electrons is divided

Q138. PHY

A cylindrical metallic wire has resistance R . If the wire is stretched so that its length is doubled and its radius is reduced to one-third of its original value, its new resistance will be:

- (A) $3R$
- (B) $9R$
- (C) $18R$
- (D) $27R$

Q139. PHY

Commercial consumption of electrical energy is calculated for consumer billing in units of:

- (A) Kilowatt
- (B) Kilowatt-hour
- (C) Megawatt
- (D) Gigawatt

Q140. PHY

Two electric light bulbs, A and B, rated at 500 W and 2000 W respectively, are connected in parallel to a 240 V power supply. The ratio of the current passing through bulb A to that passing through bulb B is:

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

Q141. PHY

A cylindrical conductor of resistivity ρ has a length equal to π meters and a circular cross-sectional radius of r meters. Its electrical resistance is:

- (A) $R = \frac{\rho}{r}$
- (B) $R = \frac{\rho}{r^2}$
- (C) $R = \frac{\rho}{r^3}$
- (D) $R = \frac{\rho}{r^4}$

Q142. PHY

When a charged particle moves into a uniform magnetic field B in a direction antiparallel to the magnetic field lines, the magnetic force acting on the particle is:

- (A) $BINA$
- (B) $Bqv \sin \theta$
- (C) Zero
- (D) $Iqtv$

Q143. PHY

When a neutron enters perpendicular to a uniform magnetic field B with velocity v , its resulting acceleration is:

- (A) Zero
- (B) Centripetal
- (C) Positive linear
- (D) Uniform and non-zero

Q144. PHY

Which of the following statements is inappropriate (false) regarding an operational step-up transformer?

- (A) It increases the given alternating voltage
- (B) It decreases the given alternating current
- (C) Heat is never produced in a step-up transformer
- (D) Its output energy is less than its input energy in practical operation

Q145. PHY

When two identical conductors, each possessing an electrical resistance R , are connected in series to an external circuit, their net equivalent resistance is:

- (A) R
- (B) $2R$
- (C) $3R$
- (D) $4R$

Q146. PHY

In a theoretical ideal AC generator where mechanical power input equals electrical power output, the rate of internal heat dissipation is:

- (A) Of some finite positive value
- (B) Zero
- (C) Maximum
- (D) Very small but non-zero

Q147. PHY

The standard SI derived unit of magnetic flux (Φ_B) is the:

- (A) Tesla
- (B) Weber
- (C) Gauss
- (D) Henry

Q148. PHY

An operating AC generator can stall and stop abruptly when:

- (A) External terminal voltage overcomes the back EMF
- (B) The counter-torque produced by the back EMF overcomes the external driving torque
- (C) Resistance of the copper coil generates excessive heat
- (D) The moment of inertia of the rotating coil decreases

Q149. PHY

The output current delivered to a load resistor by a single-diode half-wave rectifier is characterized as a/an:

- (A) Alternating current (AC)
- (B) Pulsating unidirectional current
- (C) Constant zero current
- (D) Pure smooth direct current (DC)

Q150. PHY

The dynamic forward resistance of a full-wave rectifier circuit during operational conduction is:

- (A) Less than the effective resistance of a half-wave rectifier
- (B) More than the effective resistance of a half-wave rectifier
- (C) Equal to the effective resistance of a half-wave rectifier
- (D) Negligible compared to the effective resistance of a half-wave rectifier

Q151. PHY

In the photoelectric effect, an emitted photoelectron will possess maximum kinetic energy when the incident photon has a:

- (A) Long wavelength
- (B) Short wavelength
- (C) Low frequency
- (D) Circular polarization

Q152. PHY

The electrical process of converting alternating current (AC) into direct current (DC) is termed:

- (A) Magnification
- (B) Amplification
- (C) Rectification
- (D) Resolution

Q153. PHY

In electron-positron pair annihilation, two gamma-ray photons are produced and travel in diametrically opposite directions primarily to satisfy the law of conservation of:

- (A) Energy
- (B) Linear momentum
- (C) Electric charge
- (D) Mass-energy equivalence

Q154. PHY

The electromagnetic thermal radiation emitted by warm-blooded mammals lies predominantly in which spectral region?

- (A) Visible
- (B) Ultraviolet
- (C) Infrared
- (D) X-rays

Q155. PHY

Which of the following electromagnetic photons travels with the greatest speed in a vacuum?

- (A) Gamma-ray photon
- (B) Visible light photon
- (C) Infrared photon
- (D) All photons travel with the same speed

Q156. PHY

The net vector displacement of a moving body divided by the total time elapsed during motion is defined as its:

- (A) Instantaneous velocity
- (B) Uniform velocity
- (C) Average velocity
- (D) Variable velocity

Q157. PHY

The radioactive half-life ($T_{1/2}$) of an unstable radioisotope specifies the:

- (A) Total lifespan of the entire radioactive sample
- (B) Time required for half of the radioactive parent nuclei to disintegrate
- (C) Time required for the emission of alpha particles only
- (D) Total time required for all daughter nuclei to stabilize

Q158. PHY

In a solid metallic electrical conductor, electric current is transported by the directed motion of:

- (A) Protons
- (B) Positive ions
- (C) Holes
- (D) Free electrons

Q159. PHY

The shortest possible photon wavelength in the emission spectrum of atomic hydrogen is associated with the limit of the:

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

Q160. PHY

Which of the following types of electromagnetic radiation cannot be generated by electron transitions between atomic energy levels?

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

Q161. PHY

The rate of spontaneous nuclear radioactive decay does not depend on which of the following parameters?

- (A) Initial number of radioactive parent atoms
- (B) External temperature and pressure
- (C) Chemical nature of the radioactive material
- (D) Time elapsed

Q162. PHY

Which of the following is not an accepted physical unit of radioactivity?

- (A) Becquerel (Bq)
- (B) Curie (Ci)
- (C) Decays per second
- (D) Tesla/m²

Q163. PHY

The Curie (Ci) is a measurement unit of:

- (A) Radioactivity
- (B) Temperature
- (C) Nuclear half-life
- (D) Magnetic transition intensity

Q164. PHY

Which of the following heavy elements possesses stable, non-radioactive isotopes in nature?

- (A) Lead
- (B) Plutonium
- (C) Radium
- (D) Protactinium

Q165. PHY

In physics, when a particle of matter collides with its corresponding antimatter particle, they mutually annihilate to form:

- (A) Particles with zero net electric charge
- (B) Particles with net positive electric charge
- (C) Particles with net negative electric charge
- (D) Particles with dual mass

Q166. PHY

The longest photon wavelength observed in the Balmer emission series of atomic hydrogen is:

- (A) $\frac{36}{5R_H}$
- (B) $\frac{36}{7R_H}$
- (C) $\frac{36}{11R_H}$
- (D) $\frac{36}{13R_H}$

Q167. PHY

The shortest photon wavelength in the Lyman series of atomic hydrogen (the series limit) is equal to (where R_H is the Rydberg constant):

- (A) R_H
- (B) $\frac{1}{R_H}$
- (C) $3R_H$
- (D) $\frac{5}{R_H}$

Q168. PHY

For the clinical treatment of deep-seated malignant cancers in radiation therapy, the primary radioisotope source of penetrating gamma rays is:

- (A) Co-60
- (B) I-126
- (C) Na-15
- (D) Pb-207

Q169. PHY

The velocity-time graph of a body starting from rest and moving with uniform linear acceleration is a straight line:

- (A) Not passing through the origin
- (B) Parallel to the time axis
- (C) Parallel to the velocity axis
- (D) Passing through the origin

Q170. PHY

A projectile is launched at an angle of 45° with the horizontal, producing a horizontal range R_1 . Another projectile is launched with the same initial speed at an angle of 45° with the vertical, producing a range R_2 . What is the relationship between R_1 and R_2 ?

- (A) $R_2 = 2R_1$
- (B) $R_1 = 2R_2$
- (C) $R_1 = R_2$
- (D) $3R_2 = R_1$

Q171. PHY

A cyclist comes to a skidding stop over a distance of 10 m. During this braking process, the opposing frictional force exerted on the cycle by the road is 200 N. How much mechanical work does the road do on the cycle?

- (A) -1800 J
- (B) -2000 J
- (C) +2000 J
- (D) +1900 J

Q172. PHY

The total mechanical energy of an undamped simple harmonic oscillator remains constant throughout its motion. Which of the following statements correctly describes its energy distribution?

- (A) Kinetic energy is maximum at the extreme positions
- (B) Potential energy is maximum at the extreme positions
- (C) Both kinetic and potential energy reach their minimum values at the mean position
- (D) Potential energy is maximum at the mean position

Q173. PHY

Transverse waves travel along a stretched string of length 6.0 m with a speed of 24 m/s. To which set of harmonic frequencies will the string resonate?

- (A) 1 Hz, 2 Hz, 3 Hz
- (B) 2 Hz, 4 Hz, 6 Hz
- (C) 3 Hz, 6 Hz, 9 Hz
- (D) 5 Hz, 10 Hz, 15 Hz

Q174. PHY

The apparent shift in the observed frequency of a wave caused by relative motion between the source and the observer is known as the:

- (A) Zeeman effect
- (B) Stark effect
- (C) Doppler effect
- (D) Compton effect

Q175. PHY

A simple pendulum with a bob of mass m has a period of oscillation T . If the bob is replaced by another bob of mass $3m$ while keeping the length of the suspension string unchanged, its new time period will be:

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

Q176. PHY

A wave propagates with velocity v , time period T , and frequency f . Which equation correctly expresses the relationship between frequency and time period?

- (A) $T = vf$
 - (B) $f = v + T$
 - (C) $f = \frac{1}{T}$
 - (D) $T = \frac{v}{f}$
-

ENG SECTION: ENGLISH

Questions 177 to 194 (18 MCQs)

Q177. ENG

The word 'Cowardice' is classified grammatically as a/an:

- (A) Common noun
- (B) Proper noun
- (C) Countable noun
- (D) Abstract noun

Q178. ENG

The noun 'Bridegroom' is an example of which grammatical gender category?

- (A) Neuter gender
- (B) Common gender
- (C) Masculine gender
- (D) Feminine gender

Q179. ENG

Identify the sentence structure type of the following sentence:

'I waited for the bus, but it was late.'

- (A) Simple sentence
- (B) Compound sentence
- (C) Complex sentence
- (D) Compound-complex sentence

Q180. ENG

Choose the correct preposition to complete the sentence:

'We can drive _____ the tunnel.'

- (A) By
- (B) At
- (C) Through
- (D) Into

Q181. ENG

Select the grammatically correct passive voice transformation of the active sentence:

'She needs to clean the room.'

- (A) The room needed to clean by her.
- (B) The room needed to be cleaned by her.
- (C) The room needs to be clean by her.
- (D) The room needs to be cleaned by her.

Q182. ENG

What figure of speech is employed in the sentence: *'He is the black sheep of the class.'*?

- (A) Simile
- (B) Metaphor
- (C) Alliteration
- (D) Hyperbole

Q183. ENG

Complete the sentence using the correct conditional form:

'Had I studied very well, I _____ rewarded with a scholarship.'

- (A) Was
- (B) Were
- (C) Will have been
- (D) Would have been

Q184. ENG

Choose the grammatically correct pronoun to complete the sentence:

'My brother and I met an acquaintance of _____ in the shopping mall.'

- (A) Ourselves
- (B) Us
- (C) Our
- (D) Ours

Q185. ENG

The vocabulary word 'Adept' means:

- (A) Proficient
- (B) Naive
- (C) Friend
- (D) Abode

Q186. ENG

The vocabulary word 'Frugality' means:

- (A) Economical
- (B) Enthusiasm
- (C) Foolishness
- (D) Effective

Q187. ENG

The antonym for the word 'Chaotic' is:

- (A) Embarrassing
- (B) Hectic
- (C) Orderly
- (D) Nervous

Q188. ENG

Choose the grammatically correct indirect speech for the sentence:

I said to you, 'What a nice scenery!'

- (A) I exclaimed that it was a nice scenery.
- (B) I exclaimed that it is a nice scenery.
- (C) I told you that what a nice scenery.
- (D) I told you that what was a nice scenery.

Q189. ENG

Choose the grammatically correct sentence:

- (A) No, I haven't never been to a shopping mall.
- (B) No, I haven't ever been to a shopping mall.
- (C) No, I have ever been to a shopping mall.
- (D) No, I haven't ever never been to a shopping mall.

Q190. ENG

Complete the sentence using the correct verb form:

'The child _____ spoken to his parents before going on the trip.'

- (A) Have
- (B) Will be
- (C) Had
- (D) Would

Q191. ENG

Identify the incorrect underlined word or phrase in the sentence:

'The cause (A) of the car accident can (B) have (C) been malfunctioning (D) brake pads.'

- (A) The cause
- (B) Can
- (C) Have
- (D) Malfunctioning

Q192. ENG

Choose the grammatically correct pronoun to complete the sentence:

'I am as much intelligent as _____.'

- (A) He
- (B) Himself
- (C) Him
- (D) His

Q193. ENG

Read the passage and answer the question:

'Comprehension of medical books is considered as one of the most difficult processes among understanding technical terms of diversified fields. Many studies have considered reading as a guessing activity; which means regardless of the student's level, the text will frequently contain numerous difficult words. The ability to guess and infer the meanings of unknown terminology might be viewed as a skill that should be developed.'

Based on the passage, all of the following statements are true except:

- (A) Acquiring technical jargon is difficult in technical professions, such as medical
- (B) The only reading approach used by medical students is inferring the meaning of challenging words
- (C) The technical terminology makes comprehension of medical texts challenging
- (D) Inferring the meaning of unknown words is a skill that should be developed

Q194. ENG

Read the passage and answer the question:

'People say that certain cancers are protected against by tomatoes and processed tomato products like tomato sauce and canned tomatoes. Lycopene has been found to be responsible for tomato's and tomato product's ability to prevent certain cancers. Lycopene is the vivid red pigment that gives red hue to tomatoes and other red fruits. The processed tomatoes are found to have more Lycopene. Tomato paste contains four times as much Lycopene as fresh tomatoes do because Lycopene is strongly linked to vegetable fiber and is soluble in water. Further, oil helps in absorption of Lycopene because it is a fat-soluble substance.'

It can be understood from the passage that:

- (A) Lycopene is a pigment that dissolves quickly in water and juice
- (B) Lycopene offers no protection against cancer
- (C) Tomato products contain high concentrations of fat
- (D) There is a correlation between lycopene consumption and the prevention of some cancer types

LOGIC SECTION: LOGICAL REASONING

Questions 195 to 200 (6 MCQs)

Q195. LOGIC

Read the passage below and answer the question:

'The water resources of our country are very much underutilized. The main reason behind this is the lack of capital and technology. A large portion of our water resources is wasted due to floods, unwise use of water for irrigation and domestic use. We can make full use of our water resources by building dams on rivers and through awareness campaigns among people not to waste water resources.'

Based on the passage, the inference: *'Building of dams is an essential step in the conservation of water resources'* is:

- (A) Definitely true
- (B) Probably true
- (C) Data is inadequate
- (D) Probably false

Q196. LOGIC

Read the passage below and answer the question:

'The water resources of our country are very much underutilized. The main reason behind this is the lack of capital and technology. A large portion of our water resources is wasted due to floods, unwise use of water for irrigation and domestic use. We can make full use of our water resources by building dams on rivers and through awareness campaigns among people not to waste water resources.'

Based on the passage, the inference: *'Occurrence of floods adds to the water resources'* is:

- (A) Definitely true
- (B) Probably true
- (C) Probably false
- (D) Definitely false

Q197. LOGIC

Read the passage below and answer the question:

'The water resources of our country are very much underutilized. The main reason behind this is the lack of capital and technology. A large portion of our water resources is wasted due to floods, unwise use of water for irrigation and domestic use. We can make full use of our water resources by building dams on rivers and through awareness campaigns among people not to waste water resources.'

Based on the passage, the inference: *'The country does not have enough funds to develop water resources'* is:

- (A) Definitely true
- (B) Probably true
- (C) Data is inadequate
- (D) Probably false

Q198. LOGIC

In a certain code language, the word **REMOTE** is encrypted as **ROTEME**. Which original English word would be encrypted as **PNIICC** using the same rule?

- (A) PINIC
- (B) PNIC
- (C) PICNIC
- (D) PICCIN

Q199. LOGIC

Five bags are placed in a vertical pile one on top of the other. Bag A is above bag B; bag C is above bag D but below bag E; and bag D is above bag A. Which bag occupies the exact middle position of the pile?

- (A) E
- (B) D
- (C) A
- (D) B

Q200. LOGIC

Find the term that does not fit into the established logical sequence:

1 CV, 5 FU, 9 IT, 15 LS, 17 OR

- (A) 17 OR
- (B) 5 FU
- (C) 9 IT
- (D) 15 LS

OFFICIAL VERIFIED ANSWER KEY

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

SUBJECT-WISE PERFORMANCE BREAKDOWN

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

PMDc PROVINCIAL MERIT FORMULA

Official Weightage Law:

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

Estimated Provincial Merit Aggregate: ----- %

PROPOLIS COGNITIVE ERROR AUTOPSIES

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

Question #1 Key: (C)

BIOLOGY
05. Acellular Life

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

CORE CONCEPT & DERIVATION

Viruses are obligate intracellular parasites that lack cellular machinery for independent metabolism, but they reproduce by replicating their genetic material inside a susceptible host cell.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Viruses do not carry out metabolic respiration, nutrition, or excretion, and they can be crystallized outside a host cell.
- They possess genes and replicate efficiently inside living host cells using host ribosomes and enzymes. Therefore, asserting that they lack the ability to reproduce is false.

Why other options are incorrect:

- Option A:** Viruses completely lack metabolic enzymes and mitochondria, so they do not respire.
- Option B:** Viruses do not metabolize substrates, so they generate no metabolic waste and do not excrete.
- Option D:** Outside a host, viral particles behave as chemical packages and can be crystallized.

Question #2 Key: (A)

BIOLOGY
05. Acellular Life

In 1935, W. M. Stanley prepared an extract of:

CORE CONCEPT & DERIVATION

Wendell Meredith Stanley crystallized the Tobacco Mosaic Virus (TMV) in 1935, demonstrating that viruses consist of protein and nucleic acid.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Stanley extracted and purified TMV from infected tobacco leaves in crystalline form.
- This experiment earned him a share of the 1946 Nobel Prize in Chemistry.

Why other options are incorrect:

- Option B:** HIV was discovered much later, in 1983, by Luc Montagnier and Robert Gallo.
- Option C:** The influenza virus was isolated in 1933 by Smith, Andrewes, and Laidlaw, but Stanley did not obtain its crystals in 1935.
- Option D:** Poliovirus was crystallized in 1955 by Schaffer and Schweddt.

Question #3 Key: (C)

BIOLOGY
05. Acellular Life

Human immunodeficiency virus (HIV) particles are surrounded by a coat known as the viral envelope...

CORE CONCEPT & DERIVATION

The viral envelope of enveloped animal viruses such as HIV is a lipid bilayer derived from the host plasma membrane interspersed with viral proteins, forming a lipoprotein complex.

Formula / Rule / Reaction:

Viral Envelope = Host Lipid Bilayer + Viral Glycoproteins $\equiv$ Lipoprotein Structure

Solution:

- HIV buds from the host cell membrane, acquiring a lipid bilayer embedded with gp120 and gp41 spikes.
- Because this membrane contains both lipids and proteins, it is classified chemically as a lipoprotein layer.

Why other options are incorrect:

- Option A:** Glycoproteins represent only the projecting surface spikes (gp120 and gp41), not the entire membrane bilayer.
- Option B:** Glycolipids are minor surface markers, not the structural basis of the outer envelope.
- Option D:** Sulpholipids are specialized lipids mainly found in chloroplast thylakoids, not in retroviral coats.

Question #4 Key: (B)

BIOLOGY
05. Acellular Life

The word hepatitis means inflammation of the:

CORE CONCEPT & DERIVATION

In medical terminology, the root word 'hepat-' refers to the liver, and the suffix '-itis' designates inflammation.

Formula / Rule / Reaction:

Hepat(Liver) + itis(Inflammation) = Inflammation of the Liver

Solution:

- Hepatitis is a pathological condition characterized by inflammation of liver tissue, commonly caused by viruses (HAV, HBV, HCV), alcohol, or toxins.

Why other options are incorrect:

- Option A:** Inflammation of the pancreas is termed pancreatitis.
- Option C:** Inflammation of the spleen is termed splenitis.
- Option D:** Inflammation of the gallbladder is termed cholecystitis.

Question #5 Key: (C)BIOLOGY
12. Nervous Coordination

The resting membrane potential of a typical neuron is measured at about:

CORE CONCEPT & DERIVATION

The resting membrane potential is the electrical potential difference across the axonal plasma membrane when the neuron is not conducting an impulse.

Formula / Rule / Reaction:

$$V_m = V_{\text{inside}} - V_{\text{outside}} \approx -70 \text{ mV}$$

Solution:

- The differential permeability of the membrane to K^+ over Na^+ , combined with the electrogenic action of the Na^+/K^+ ATPase pump, maintains an interior negative charge.
- In human neurons, this resting potential is calibrated at -70 mV .

Why other options are incorrect:

- Option A:** -30 mV is an intermediate depolarization stage, not the resting potential.
- Option B:** -50 mV corresponds closely to the threshold potential required to trigger an action potential.
- Option D:** -100 mV is too negative, exceeding the potassium equilibrium potential (approximately -90 mV).

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

In aerobic respiration, the glucose molecule is completely broken down into carbon dioxide (CO_2).

CORE CONCEPT & DERIVATION

Aerobic respiration of one mole of glucose yields a theoretical maximum of 36 ATP in typical eukaryotic cells when the glycerol phosphate shuttle transfers cytosolic electrons into mitochondria.

Formula / Rule / Reaction:



Solution:

- Glycolysis yields 2 net ATP and 2 NADH.
- In eukaryotic cells utilizing the glycerol phosphate shuttle, 2 cytosolic NADH enter the electron transport chain as $FADH_2$, yielding 4 ATP.
- The transition step and Krebs cycle produce 2 ATP (substrate level), 8 mitochondrial NADH (yielding 24 ATP), and 2 $FADH_2$ (yielding 4 ATP).
- Total net ATP yield equals $2 + 4 + 2 + 24 + 4 = 36 \text{ ATP}$.

Why other options are incorrect:

- Option A:** 2 ATP represents the net yield of anaerobic glycolysis alone.
- Option B:** 4 ATP is the gross ATP produced during glycolysis, not complete respiration.
- Option C:** 34 ATP is the yield from oxidative phosphorylation alone, omitting substrate-level phosphorylation.

Question #7 Key: (C)BIOLOGY
02. Biomolecules

The four types of fundamental biological molecules present in protoplasm are carbohydrates, proteins, lipids, and nucleic acids.

CORE CONCEPT & DERIVATION

The biochemical foundation of all living matter rests on four primary classes of organic macromolecules: carbohydrates, lipids, proteins, and nucleic acids.

Formula / Rule / Reaction:

$$\text{Primary Biomolecules} = \{\text{Carbohydrates, Lipids, Proteins, Nucleic Acids}\}$$

Solution:

- Nucleic acids (DNA and RNA) serve as the informational macromolecules that direct protein synthesis and heredity.
- Together with proteins, lipids, and carbohydrates, they constitute the four fundamental organic building blocks of cellular protoplasm.

Why other options are incorrect:

- Option A:** Enzymes are functional derivatives of proteins, not an independent fourth class.
- Option B:** Hormones are specialized regulatory molecules derived from proteins, amino acids, or lipids.
- Option D:** Alkaloids are secondary plant metabolites, not universal primary macromolecules of protoplasm.

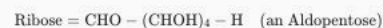
Question #8 Key: (A)BIOLOGY
02. Biomolecules

Ribose is a pentose sugar (5 carbon) that contains an aldehyde group.

CORE CONCEPT & DERIVATION

Monosaccharides are classified as aldoses or ketoses based on whether their carbonyl functional group is an aldehyde or a ketone.

Formula / Rule / Reaction:



Solution:

- Ribose has five carbons with a terminal carbonyl group at carbon-1 ($-\text{CHO}$).
- This structural arrangement defines it as an aldopentose sugar containing an aldehyde group.

Why other options are incorrect:

- Option B:** Ribulose contains a ketone group at carbon-2, whereas ribose is an aldose.
- Option C:** Carboxyl groups ($-\text{COOH}$) are characteristic of organic acids, not unmodified monosaccharides.
- Option D:** Ester groups form when sugars bond with phosphate groups; they are not an inherent functional group of free ribose.

Question #9 Key: (C)BIOLOGY
02. Biomolecules

Proteins are macromolecules formed of units known as amino acids. The amino acid in which the v...

CORE CONCEPT & DERIVATION

All twenty standard alpha amino acids share a general backbone structure, distinguished exclusively by the chemical identity of their side chain (R group).

Formula / Rule / Reaction:

General Structure: $\text{H}_2\text{N} - \text{CH}(\text{R}) - \text{COOH}$; If $\text{R} = -\text{H} \Rightarrow$ Glycine

Solution:

- In glycine, the R group is a single hydrogen atom, making it the simplest amino acid.
- Because its alpha carbon is bonded to two identical hydrogen atoms, glycine is also the only non-chiral standard amino acid.

Why other options are incorrect:

- Option A:** Lysine has a butylamino side chain, $-(\text{CH}_2)_4 - \text{NH}_2$.
- Option B:** Phenylalanine has a benzyl side chain, $-\text{CH}_2 - \text{C}_6\text{H}_5$.
- Option D:** Alanine has a methyl side chain, $-\text{CH}_3$.

Question #10 Key: (C)BIOLOGY
02. Biomolecules

The type of lipids which do not contain fatty acids are:

CORE CONCEPT & DERIVATION

Lipids are structurally diverse; nonsaponifiable lipids lack ester linkages and do not contain fatty acid hydrocarbon chains.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Steroids are composed of a characteristic fused carbon framework of four rings (cyclopentanoperhydrophenanthrene ring system).
- They do not contain fatty acid chains or ester linkages in their core structure.

Why other options are incorrect:

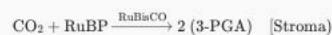
- Option A:** Phospholipids contain two fatty acid tails esterified to a glycerol molecule.
- Option B:** Waxes are esters of long-chain fatty acids with long-chain aliphatic alcohols.
- Option D:** Acylglycerols consist of one, two, or three fatty acid molecules esterified to glycerol.

Question #11 Key: (B)BIOLOGY
04. Bioenergetics

In which part of the chloroplast does the fixation of carbon dioxide result in the formation of...

CORE CONCEPT & DERIVATION

Photosynthesis consists of light-dependent reactions situated in the thylakoid membranes and light-independent carbon fixation reactions occurring in the stroma.

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

- The Calvin cycle enzymes, including RuBisCO, are dissolved in the aqueous fluid surrounding thylakoids, known as the stroma.
- Carbon dioxide fixation, reduction of 3-PGA, and regeneration of RuBP take place directly within the stroma.

Why other options are incorrect:

- Option A:** Grana host the light-dependent reactions, photolysis of water, and photophosphorylation.
- Option C:** Intergranal thylakoids connect granal stacks and house photosystem I components.
- Option D:** The outer chloroplast membrane serves as a boundary and contains porins for transport.

Question #12 Key: (C)BIOLOGY
01. Cell

The colloidal mixture of ions, organic, and inorganic salts present in the nucleus is called:

CORE CONCEPT & DERIVATION

The nucleoplasm (also known as nuclear sap or karyoplasm) is the clear, viscous colloidal matrix enclosed by the nuclear envelope.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Nucleoplasm is a specialized protoplasmic ground substance containing water, nucleotides, structural proteins, enzymes (DNA and RNA polymerases), and mineral ions.
- It suspends the chromatin network and the nucleolus within the nuclear envelope.

Why other options are incorrect:

- Option A:** The nuclear membrane is the double-bilayer lipid envelope enclosing the nucleus.
- Option B:** The nucleolus is a dense, non-membrane-bound subnuclear structure responsible for ribosome biogenesis.
- Option D:** Chromosomes are organized, compact complexes of DNA and histone proteins.

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

Those nerves that originate from or lead directly to the brain are called cranial nerves. There...

CORE CONCEPT & DERIVATION

The peripheral nervous system in humans comprises cranial nerves arising directly from the brain and spinal nerves arising from segments of the spinal cord.

Formula / Rule / Reaction:

Cranial Nerves = 12 pairs; Spinal Nerves = 31 pairs

Solution:

- Humans possess exactly 12 pairs of cranial nerves (designated I through XII), including the olfactory, optic, and vagus nerves.

Why other options are incorrect:

- Option A:** 6 pairs is incorrect for humans.
- Option C:** 14 pairs is incorrect.
- Option D:** 31 pairs is the count of human spinal nerves, not cranial nerves.

Question #14 Key: (C)BIOLOGY
13. Chemical Coordination

The hormone that triggers the release (let-down) of milk in lactating women is:

CORE CONCEPT & DERIVATION

Lactation involves two primary hormonal controls: prolactin stimulates the synthesis of milk, whereas oxytocin stimulates milk ejection.

Formula / Rule / Reaction:

Suckling Stimulus → Hypothalamus → Posterior Pituitary $\xrightarrow{\text{Oxytocin}}$ Myoepithelial Contraction → Milk Ejection

Solution:

- Oxytocin induces contraction of myoepithelial cells surrounding mammary alveoli, ejecting milk into lactiferous ducts.
- This physiological response is termed the milk let-down reflex.

Why other options are incorrect:

- Option A:** Growth hormone regulates somatic growth and cellular metabolism.
- Option B:** Antidiuretic hormone (vasopressin) regulates renal water reabsorption.
- Option D:** Follicle stimulating hormone (FSH) stimulates ovarian follicular growth and spermatogenesis.

Question #15 Key: (A)BIOLOGY
10. Homeostasis

The group of organisms possessing a single-celled body that performs all the vital activities o...

CORE CONCEPT & DERIVATION

Protozoa are eukaryotic, predominantly unicellular organisms in which a single individual cell conducts all locomotion, feeding, excretion, and reproduction.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The term 'Protozoa' refers to unicellular, animal-like protists.
- All necessary physiological life processes are executed intracellularly within specialized organelles.

Why other options are incorrect:

- Option B:** Parazoa consists of multicellular animals lacking true tissues (sponges).
- Option C:** Metazoa includes all multicellular animals with differentiated cells and tissues.
- Option D:** Nanozoa is not a recognized taxonomic animal subkingdom.

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

The word 'Annelida' is of Latin origin; 'annellus' means:

CORE CONCEPT & DERIVATION

Phylum Annelida derives its name from the Latin word 'annellus', reflecting the superficial rings that segment their cylindrical bodies.

Formula / Rule / Reaction:

Latin: *annellus* = little ring

Solution:

- Annelids exhibit metameric segmentation where the external body is divided into repetitive ring-like segments.
- Hence, Lamarck coined the name from 'annellus', meaning little ring.

Why other options are incorrect:

- Option B:** Segmented body describes their anatomical plan, but the literal Latin translation of 'annellus' is little ring.
- Option C:** Thread is the literal translation of the Greek root 'nema', which gives name to Nematoda.
- Option D:** Hollow is the literal translation of 'coel-', as in Coelenterata.

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

Most of the coenzymes are derivatives of:

CORE CONCEPT & DERIVATION

Coenzymes are non-protein organic cofactors that reversibly bind to enzymes during catalytic cycles, many of which are synthesized from water-soluble vitamins.

Formula / Rule / Reaction:

Examples: Niacin $\rightarrow$ NAD⁺; Riboflavin(B₂) $\rightarrow$ FAD; Pantothenic acid(B₅) $\rightarrow$ CoA

Solution:

- The majority of essential coenzymes in cellular metabolism are chemically modified vitamins, particularly members of the vitamin B complex.

Why other options are incorrect:

- Option A:** Lipids serve as energy reserves, cellular barriers, and membrane components, not as coenzymes.
- Option C:** Steroids function as structural membrane regulators and signalling hormones.
- Option D:** Waxes function as protective, water-repellent barriers.

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

Genetic drift is the change in the allele frequency of a population due to:

CORE CONCEPT & DERIVATION

Genetic drift is an evolutionary mechanism producing stochastic fluctuations in allele frequencies from one generation to the next due to sampling error.

Formula / Rule / Reaction:

$$\Delta p_{\text{drift}} \propto \frac{1}{2N_e} \quad (\text{driven by chance events in finite populations})$$

Solution:

- Unlike natural selection, genetic drift does not select for adaptive traits.
- It is entirely driven by random chance events, such as the bottleneck effect or founder effect, and is most pronounced in small populations.

Why other options are incorrect:

- Option B:** Non-random mating alters genotypic frequencies without directly shifting overall allele frequencies.
- Option C:** Natural selection causes directional shifts in allele frequencies based on differential reproductive fitness.
- Option D:** Artificial selection involves intentional human intervention to breed specific phenotypic traits.

Question #19 Key: (C)BIOLOGY
16. Evolution

The basis of Lamarck's theory of evolution is:

CORE CONCEPT & DERIVATION

Jean-Baptiste Lamarck proposed that structural modifications acquired by an individual through the use or disuse of organs during its lifetime are transmitted to its offspring.

Formula / Rule / Reaction:

Environmental Demand $\rightarrow$ Use/Disuse $\rightarrow$ Acquired Modification $\rightarrow$ Inherited by Offspring

Solution:

- Lamarckism relies on two central hypotheses: the principle of use and disuse, and the inheritance of acquired characters.

Why other options are incorrect:

- Option A:** Survival of the fittest was formulated by Herbert Spencer and incorporated into Darwin's theory.
- Option B:** Natural selection is the core concept of Darwinian evolution.
- Option D:** Special creation is a theological doctrine asserting that species were created instantaneously and remain immutable.

Question #20 Key: (D)BIOLOGY
09. Respiration / Gaseous Exchange

Which one of the following parts of the human respiratory system forms the actual gas exchange ...

CORE CONCEPT & DERIVATION

The respiratory tract is anatomically divided into a conducting zone that routes air and a respiratory zone where gas diffusion between air and blood occurs.

Formula / Rule / Reaction:

Gas Diffusion: O₂ and CO₂ across the 0.5 μ m Respiratory Membrane of Alveoli

Solution:

- Alveoli are microscopic, thin-walled, sac-like structures lined with simple squamous epithelium and wrapped in extensive capillary networks.
- They form the true respiratory surface across which oxygen diffuses into blood and carbon dioxide enters the airway.

Why other options are incorrect:

- Option A:** The trachea is a cartilage-reinforced conducting tube.
- Option B:** The larynx functions as the sound-producing organ (voice box) and guards the lower tract.
- Option C:** Bronchi are branching conducting conduits distributing air into the lung lobes.

Question #21 **Key: (B)**BIOLOGY
09. Respiration / Gaseous Exchange

The average adult human has a total lung capacity of approximately:

CORE CONCEPT & DERIVATION

Total lung capacity (TLC) is the maximum volume of air the lungs can accommodate following a maximal inspiratory effort.

Formula / Rule / Reaction:

$$\text{TLC} = \text{Vital Capacity (VC)} + \text{Residual Volume (RV)} \approx 4.5 \text{ to } 5.0 \text{ Litres}$$

Solution:

- In typical adult humans, vital capacity is approximately 3.5 to 4.5 litres, and residual volume is approximately 1.2 litres.
- The resulting total lung capacity measures around 5 litres (commonly cited between 5 and 6 litres in standard physiology texts).

Why other options are incorrect:

- Option A:** 2 litres is near the normal functional residual capacity, well below total capacity.
- Option C:** 9 litres far exceeds normal physiological lung capacity in humans.
- Option D:** 12 litres is pathologically impossible in the human thoracic cavity.

Question #22 **Key: (D)**BIOLOGY
14. Reproduction

The process of spermatogenesis (formation of sperm) takes place in which part of the male repro...

CORE CONCEPT & DERIVATION

Spermatogenesis is the developmental process wherein spermatogonia undergo mitotic proliferation, meiosis, and spermiogenesis within specialized testicular tubules.

Formula / Rule / Reaction:

$$\text{Spermatogonia} \xrightarrow{\text{Mitosis}} 1^\circ \text{ Spermatocyte} \xrightarrow{\text{Meiosis}} 2^\circ \text{ Spermatocytes} \rightarrow \text{Spermatids} \xrightarrow{\text{Spermiogenesis}} \text{Spermatozoa} \quad \text{Synovial Joint} = \text{Articular Capsule} + \text{Synovial Fluid Cavity} + \text{Articular Cartilage}$$

Solution:

- Seminiferous tubules make up the bulk of testicular tissue.
- Their germinal epithelial lining contains Sertoli cells that nurse germ cells as they develop into mature spermatozoa.

Why other options are incorrect:

- Option A:** The urethra conveys both semen and urine out of the body.
- Option B:** The epididymis functions in storing and maturation of sperm, conferring physiological motility.
- Option C:** The oviduct (fallopian tube) is an anatomical component of the female reproductive tract.

Question #23 **Key: (A)**BIOLOGY
14. Reproduction

Which one of the following cells possesses a haploid (n) number of chromosomes?

CORE CONCEPT & DERIVATION

Somatic cells are diploid (2n), maintaining two sets of homologous chromosomes, whereas mature gametes produced by meiotic division contain a single set of chromosomes (n).

Formula / Rule / Reaction:

$$\text{Somatic Cells} = 2n = 46; \quad \text{Gametes (Sperm/Ovum)} = n = 23$$

Solution:

- A sperm cell is a mature male gamete that has undergone both meiotic reduction divisions.
- In humans, it carries exactly 23 single chromosomes, making it haploid.

Why other options are incorrect:

- Option B:** Mesophyll cells are vegetative plant cells that contain the full diploid complement.
- Option C:** Skin cells (keratinocytes) are somatic cells possessing 46 chromosomes (2n).
- Option D:** Muscle cells are somatic cells containing diploid nuclei.

Question #24 **Key: (C)**BIOLOGY
11. Support & Movement

Those joints in which the articulating bones are separated by a fluid-containing joint cavity a...

CORE CONCEPT & DERIVATION

Joints are structurally classified into fibrous, cartilaginous, and synovial joints depending on the tissue connecting the bones and the presence of a joint cavity.

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

- Synovial joints feature a distinct fluid-filled synovial cavity surrounded by an articular capsule.
- This fluid lubricates the joint, allowing free movement (diarthrosis).

Why other options are incorrect:

- Option A:** Fibrous joints connect bones via dense collagen fibers without a cavity (e.g., cranial sutures).
- Option B:** Cartilaginous joints unite bones with hyaline cartilage or fibrocartilage, lacking a fluid cavity.
- Option D:** Immovable joints (synarthroses) exhibit no fluid cavity and permit no movement.

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

The joints present in the human elbow and knee are examples of which type of joint?

CORE CONCEPT & DERIVATION

A hinge joint is a uniaxial synovial joint that allows motion in only one plane, analogous to the movement of a hinged door.

Formula / Rule / Reaction:

Hinge Joint = Uniaxial Motion (Flexion and Extension in a Single Plane)

Solution:

- The knee and elbow permit angular flexion and extension within a single plane.
- Therefore, they are classified anatomically as hinge joints.

Why other options are incorrect:

- **Option A:** Immovable joints allow no functional motion (e.g., sutures of the cranium).
- **Option B:** Slightly movable joints permit limited movement (e.g., intervertebral discs).
- **Option D:** Ball and socket joints permit multi-axial rotation in multiple planes (e.g., hip and shoulder).

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

A man of blood group A marries a woman of blood group B, and they have one child. Which one of ...

CORE CONCEPT & DERIVATION

The ABO blood group system is governed by multiple alleles (I^A , I^B , i), where I^A and I^B are codominant with each other and completely dominant over the recessive allele i .

Formula / Rule / Reaction:

Cross: $I^A i \times I^B i \rightarrow I^A I^B$ (AB), $I^A i$ (A), $I^B i$ (B), ii (O)

Solution:

- If the father is heterozygous for blood group A (genotype $I^A i$) and the mother is heterozygous for blood group B (genotype $I^B i$), their child can inherit any combination of alleles: $I^A I^B$, $I^A i$, $I^B i$, or ii .
- These combinations correspond to blood groups AB, A, B, and O, respectively.

Why other options are incorrect:

- **Option A:** Blood group A is only one of four possible outcomes.
- **Option B:** Blood group AB occurs if both parents are homozygous, but heterozygous parents can produce other phenotypes.
- **Option C:** This option omits the possible expression of AB and O.

Question #27 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

Red-green colour blindness is a recessive sex-linked trait that renders individuals unable to d...

CORE CONCEPT & DERIVATION

In red-green colour blindness (protanopia/deutanopia), the absence of functional red or green cone photopigments prevents differential spectral processing, causing reds and greens to be perceived as neutral grey or brownish-grey tones.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Because the brain cannot compare inputs across the red and green cone absorption bands, signals in this wavelength range fail to generate color contrast.
- As stated in the KP provincial textbook, affected individuals perceive these shades similarly as shades of grey.

Why other options are incorrect:

- **Option A:** The subject cannot perceive red distinctively because the relevant photopigment or comparison mechanism is impaired.
- **Option B:** The subject cannot perceive green distinctively.
- **Option D:** While yellow tones may be seen in the intermediate spectrum, the textbook specifies that both colors appear as shades of grey.

Question #28 Key: (D)BIOLOGY
01. Cell

The statement 'the membrane is like a sea of lipids in which proteins are floating' represents ...

CORE CONCEPT & DERIVATION

The Fluid Mosaic Model proposed by S. J. Singer and Garth L. Nicolson in 1972 describes biological membranes as a fluid phospholipid matrix with embedded globular proteins.

Formula / Rule / Reaction:

Fluid Mosaic Model: Fluid Phospholipid Bilayer + Integral/Peripheral Proteins

Solution:

- Singer and Nicolson described proteins as floating like 'icebergs in a sea of lipids'.
- This model accounts for the lateral mobility of both lipids and proteins within the membrane plane.

Why other options are incorrect:

- **Option A:** Gorter and Grendel (1925) deduced that the membrane is a simple phospholipid bilayer based on surface area measurements of red blood cells.
- **Option B:** Danielli and Davson (1935) proposed a static sandwich model with a lipid core coated by continuous protein sheets.
- **Option C:** J. D. Robertson (1959) proposed the 'Unit Membrane' model based on trilaminar electron micrographs.

Question #29 Key: (D)BIOLOGY
01. Cell

Detoxification of drugs and harmful chemicals is a major function of the:

CORE CONCEPT & DERIVATION

The smooth endoplasmic reticulum (SER) contains enzymes, including the cytochrome P450 family, that convert hydrophobic drugs and metabolic toxins into water-soluble derivatives for excretion.

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

- In hepatocytes, the SER is well developed and carries out extensive chemical detoxification.
- It hydroxylates harmful compounds, increasing their water solubility so they can be filtered by the kidneys.

Why other options are incorrect:

- **Option A:** Golgi bodies modify, sort, and package proteins and lipids into secretory vesicles.
- **Option B:** Mitochondria generate ATP through oxidative phosphorylation and the citric acid cycle.
- **Option C:** The rough endoplasmic reticulum synthesizes proteins destined for membranes, lysosomes, or secretion.

Question #30 Key: (D)BIOLOGY
01. Cell

Chloroplasts contain:

CORE CONCEPT & DERIVATION

Chloroplasts are semi-autonomous organelles originating through endosymbiosis; they maintain their own genome and protein synthesis machinery.

Formula / Rule / Reaction:

Semi-autonomous Organelle = Circular DNA + 70S Ribosomes + Enzymatic Proteins

Solution:

- Chloroplasts possess circular double-stranded DNA, 70S ribosomes, and the enzymes required for transcription and translation of organellar proteins.
- Therefore, all three components (proteins, ribosomes, and circular DNA) are present.

Why other options are incorrect:

- **Option A:** Restricting chloroplast contents to proteins omits their nucleic acids and ribosomes.
- **Option B:** Restricting chloroplast contents to ribosomes overlooks their DNA and metabolic proteins.
- **Option C:** Restricting chloroplast contents to DNA ignores their translational machinery and enzymes.

Question #31 Key: (C)BIOLOGY
08. Immunity

Mitochondria were first observed as intracellular granules in:

CORE CONCEPT & DERIVATION

Albert von Kölliker discovered mitochondria in 1857 while studying striated muscle cells, observing them as distinct cytoplasmic granules.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Kölliker isolated these granules from the sarcoplasm of insect and mammalian striated muscles, where they were termed sarcosomes.
- Later, Carl Benda coined the term 'mitochondria' in 1898.

Why other options are incorrect:

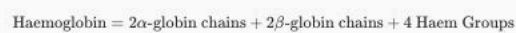
- **Option A:** White blood cells were not the tissue in which Kölliker first identified these granules.
- **Option B:** Mature mammalian red blood cells lack mitochondria entirely.
- **Option D:** While liver cells are rich in mitochondria, they were not the tissue of initial histological discovery.

Question #32 Key: (B)BIOLOGY
02. Biomolecules

Haemoglobin is classified chemically as a:

CORE CONCEPT & DERIVATION

Haemoglobin is a conjugated globular protein with a quaternary structure composed of four polypeptide subunits, each bound to an iron-containing haem prosthetic group.

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

- Haemoglobin is an oxygen-transport chromoprotein found in red blood cells.
- Its polypeptide chains fold into compact, water-soluble globular domains.

Why other options are incorrect:

- **Option A:** Carbohydrates are polyhydroxy aldehydes or ketones, not amino acid polymers.
- **Option C:** Nucleic acids are polymers of nucleotides (DNA and RNA).
- **Option D:** Haemoglobin binds and transports oxygen reversibly without catalyzing chemical transformation of a substrate.

Question #33 Key: (A)BIOLOGY
02. Biomolecules

Glycerol is an alcohol containing how many carbon atoms?

CORE CONCEPT & DERIVATION

Glycerol is a trihydric alcohol that forms the backbone of triacylglycerols and phosphoglycerides.

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

- Glycerol contains a three-carbon chain, with a hydroxyl group attached to each carbon atom.

Why other options are incorrect:

- Option B:** Four carbons corresponds to erythritol or butane-based polyols.
- Option C:** Five carbons corresponds to pentitols such as xylitol.
- Option D:** Six carbons corresponds to hexitols such as sorbitol or mannitol.

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

Enzymes are almost exclusively _____ in chemical nature.

CORE CONCEPT & DERIVATION

Enzymes are biological catalysts that increase the rate of biochemical reactions, and with few exceptions (such as catalytic RNA ribozymes), they are globular proteins.

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

- Enzymes fold into complex tertiary and quaternary conformations to establish functional catalytic sites (active sites).
- Their chemical properties, specificity, and susceptibility to heat or pH changes stem from their protein nature.

Why other options are incorrect:

- Option A:** Carbohydrates provide structural support and metabolic fuel, not enzymatic catalysis.
- Option C:** Lipids form membrane bilayers and energy stores.
- Option D:** Vitamins act as precursors for cofactors, but they do not form the catalytic enzyme body.

Question #35 Key: (C)BIOLOGY
04. Bioenergetics

The range of wavelengths that constitutes the visible light spectrum is approximately:

CORE CONCEPT & DERIVATION

The visible light spectrum includes electromagnetic radiation detectable by the human eye, spanning from violet to red.

Formula / Rule / Reaction:

$$\lambda_{\text{visible}} \approx 380 \text{ nm (Violet)} \text{ to } 750 \text{ nm (Red)}$$

Solution:

- The electromagnetic spectrum visible to humans and used in photosynthesis ranges from approximately 380 nm to 750 nm.

Why other options are incorrect:

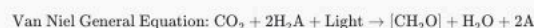
- Option A:** 300 nm falls in the invisible ultraviolet-B band.
- Option B:** 350 nm is in the near-ultraviolet range, and 700 nm excludes part of the far-red spectrum.
- Option D:** 430 nm omits violet wavelengths, and 790 nm extends into the infrared.

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

Which scientist hypothesized that plants split water to release oxygen as a by-product during p...

CORE CONCEPT & DERIVATION

Cornelis Bernardus van Niel deduced that oxygen released during plant photosynthesis comes from the photolysis of water, drawing an analogy to purple sulphur bacteria that use H_2S and release sulphur.

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

- Van Niel observed that sulphur bacteria convert $\text{CO}_2 + 2\text{H}_2\text{S} \rightarrow [\text{CH}_2\text{O}] + \text{H}_2\text{O} + 2\text{S}$.
- From this, he reasoned that in green plants where H_2O replaces H_2S , molecular oxygen originates from water rather than from carbon dioxide.

Why other options are incorrect:

- Option B:** Trofim Lysenko was a Soviet agronomist known for rejecting Mendelian genetics.
- Option C:** Melvin Calvin mapped the photosynthetic carbon-reduction cycle (Calvin cycle).
- Option D:** Hans Krebs discovered the citric acid cycle of aerobic respiration.

Question #37 Key: (B)BIOLOGY
04. Bioenergetics

The Calvin cycle operates in how many primary stages?

CORE CONCEPT & DERIVATION

The dark reactions of photosynthesis proceed through three coordinated stages in the chloroplast stroma to convert carbon dioxide into triose phosphates.

Formula / Rule / Reaction:

Stage 1: Carbon Fixation → Stage 2: Reduction → Stage 3: Regeneration of RuBP

Solution:

- Stage 1: Carbon fixation, where CO_2 combines with RuBP using RuBisCO.
- Stage 2: Reduction, where 3-PGA is converted to G3P using ATP and NADPH.
- Stage 3: Regeneration, where G3P molecules are rearranged using ATP to regenerate the CO_2 acceptor RuBP.

Why other options are incorrect:

- **Option A:** Describing the cycle in two stages fails to distinguish reduction from regeneration of the acceptor molecule.
- **Option C:** Four stages is an unnecessary subdivision of the primary biochemical steps.
- **Option D:** Five stages does not match standard textbook descriptions of the cycle.

Question #38 Key: (C)BIOLOGY
05. Acellular Life

Which of the following pairs of human diseases are both caused by viruses?

CORE CONCEPT & DERIVATION

Infectious diseases are classified by the nature of their causative agents: viruses, bacteria, protozoa, or fungi.

Formula / Rule / Reaction:

Measles (Morbillivirus) and Mumps (Rubulavirus) ⇒ Both are Paramyxoviruses

Solution:

- Measles is caused by an enveloped RNA paramyxovirus (morbillivirus).
- Mumps is likewise caused by an RNA paramyxovirus (rubulavirus). Thus, both are viral diseases.

Why other options are incorrect:

- **Option A:** Syphilis is caused by the bacterium *Treponema pallidum*, and TB is caused by the bacterium *Mycobacterium tuberculosis*.
- **Option B:** AIDS is caused by the virus HIV, but typhoid is caused by the bacterium *Salmonella typhi*.
- **Option D:** Tetanus (*Clostridium tetani*) and cholera (*Vibrio cholerae*) are both bacterial diseases.

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

The terminal portion of the human male reproductive duct system that conveys semen to the exterior...

CORE CONCEPT & DERIVATION

Sperm follow a sequential pathway through the male duct system: seminiferous tubules to rete testis, vasa efferentia, epididymis, vas deferens, ejaculatory duct, and finally the urethra.

Formula / Rule / Reaction:

Testis → Epididymis → Vas Deferens → Ejaculatory Duct → Urethra (Terminal Conduit)

Solution:

- The urethra runs through the prostate and the penis, opening at the external urethral orifice.
- It serves as the final common duct for both the reproductive and urinary systems in males.

Why other options are incorrect:

- **Option A:** Vasa efferentia convey immature spermatozoa from the rete testis to the epididymis.
- **Option B:** The vas deferens transports mature sperm from the epididymis to the ejaculatory duct.
- **Option D:** The epididymis is the site for sperm storage and functional maturation.

Question #40 Key: (C)BIOLOGY
01. Cell

The cell wall of true bacteria (eubacteria) is primarily composed of:

CORE CONCEPT & DERIVATION

The cell wall of eubacteria is a rigid macromolecular mesh consisting of repeating disaccharide units cross-linked by short amino acid peptide chains.

Formula / Rule / Reaction:

Peptidoglycan (Murein) = $[\text{N-acetylglucosamine (NAG)} - \text{N-acetylmuramic acid (NAM)}]_n + \text{F}$

Solution:

- Peptidoglycan (also known as murein) forms the structural backbone of bacterial cell walls, protecting against osmotic lysis.

Why other options are incorrect:

- **Option A:** Chitin is a polymer of N-acetylglucosamine found in fungal cell walls and arthropod exoskeletons.
- **Option B:** Cellulose is a polymer of beta-D-glucose found in plant and algal cell walls.
- **Option D:** Pectin is a structural heteropolysaccharide found in the middle lamella and primary cell walls of plants.

Question #41 Key: (D)BIOLOGY
06. Digestion/Nutrition

Which one of the following is not a carnivorous (insectivorous) plant?

CORE CONCEPT & DERIVATION

Carnivorous plants are specialized autotrophs adapted to nitrogen-deficient soils by trapping and digesting small insects using modified leaves.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The money plant (*Epipremnum aureum*) is an ornamental climbing vine that absorbs nutrients from the soil like typical non-carnivorous plants.

Why other options are incorrect:

- Option A:** The pitcher plant (*Sarracenia / Nepenthes*) uses modified pitfall traps to catch insects.
- Option B:** The sundew (*Drosera*) uses glandular tentacles covered in sticky digestive secretions.
- Option C:** The butterwort (*Pinguicula*) uses sticky glandular leaves to capture and digest small prey.

Question #42 Key: (C)BIOLOGY
11. Support & Movement

All of the following are characteristics of cartilage except:

CORE CONCEPT & DERIVATION

Cartilage is an avascular skeletal connective tissue consisting of chondrocytes embedded in an extracellular matrix rich in chondroitin sulfate and collagen.

Formula / Rule / Reaction:Cartilage Architecture: Avascular $\Rightarrow$ Nutrient Delivery via Diffusion from Perichondrium**Solution:**

- Cartilage contains no internal blood vessels (it is avascular).
- Nutrients and oxygen must diffuse through the matrix from the surrounding perichondrium, which is why cartilage repairs slowly after injury.

Why other options are incorrect:

- Option A:** Cartilage is classified histologically as specialized connective tissue.
- Option B:** Chondroblasts differentiate into mature chondrocytes, which maintain the tissue matrix.
- Option D:** Slow healing is an established consequence of its avascular nature.

Question #43 Key: (D)BIOLOGY
11. Support & Movement

Which one of the following is not a recognized feature or classification of arthritis?

CORE CONCEPT & DERIVATION

Arthritis encompasses inflammatory conditions that affect joints, whereas inflammation of a peripheral nerve is called neuritis.

Formula / Rule / Reaction:

Arthritis = Joint Inflammation; Neuritis = Nerve Inflammation

Solution:

- Inflammation of a nerve is called neuritis.
- Arthritis involves inflammation, swelling, and pain localized to joints and articular cartilages.

Why other options are incorrect:

- Option A:** Joint inflammation is the core clinical definition of arthritis.
- Option B:** Rheumatoid arthritis is an established autoimmune joint disorder.
- Option C:** Degenerative osteoarthritis is a leading contributor to musculoskeletal disability in elderly populations.

Question #44 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics

A clear genetic exception to Mendel's Law of Independent Assortment is:

CORE CONCEPT & DERIVATION

Mendel's Law of Independent Assortment holds that alleles of different genes segregate independently during gamete formation, which is true only if the genes reside on different chromosomes or are far apart on the same chromosome.

Formula / Rule / Reaction:Complete Linkage $\Rightarrow$ Alleles on the Same Chromosome Inherited Together $\neq 9 : 3 : 3 : 1$ **Solution:**

- Linked genes reside syntenically on the same chromosome and tend to be inherited together as a unit during meiosis.
- This physical linkage prevents them from assorting independently, modifying typical Mendelian dihybrid ratios.

Why other options are incorrect:

- Option B:** Dominance describes how one allele can mask the phenotypic expression of another at the same locus.
- Option C:** Purity of gametes is an alternative term for Mendel's Law of Segregation, stating that each gamete carries only one allele.
- Option D:** Segregation is a fundamental Mendelian principle, not an exception to independent assortment.

Question #45 Key: (C)BIOLOGY
11. Support & Movement

The hollow, elongated transverse invaginations formed when the sarcolemma of a muscle fibre pen...

CORE CONCEPT & DERIVATION

Transverse tubules (T-tubules) are tubular extensions of the muscle cell membrane (sarcolemma) that conduct electrical action potentials into the interior of the muscle fiber.

Formula / Rule / Reaction:

Depolarization of Sarcolemma → T-Tubule Propagation → DHP-RyR Coupling → Ca^{2+} Release from SR

Solution:

- T-tubules run transversely across the fiber at the junctions of the A and I bands.
- They allow surface action potentials to reach deep myofibrils rapidly, triggering synchronous release of calcium from terminal cisternae.

Why other options are incorrect:

- **Option A:** 'A tubule' is not an anatomical component of striated muscle.
- **Option B:** 'M tubule' does not exist; the M line is a structural protein line in the H zone.
- **Option D:** 'Z tubule' is incorrect; the Z disc serves as the anchor point for actin filaments.

Question #46 Key: (A)BIOLOGY
12. Nervous Coordination

The type of neuron that conducts nerve impulses from sensory receptors and peripheral tissues t...

CORE CONCEPT & DERIVATION

Neurons are functionally classified by the direction of impulse transmission: afferent (sensory) neurons convey impulses toward the CNS, whereas efferent (motor) neurons transmit impulses away from the CNS.

Formula / Rule / Reaction:

Sensory Receptor $\xrightarrow{\text{Sensory (Afferent) Neuron}}$ Central Nervous System (Spinal Cord/Brain)

Solution:

- Sensory neurons detect environmental stimuli and transmit sensory input as action potentials into the central nervous system.

Why other options are incorrect:

- **Option B:** Motor neurons transmit motor commands away from the CNS to effector organs like muscles or glands.
- **Option C:** Intermediate neurons (interneurons) link sensory and motor neurons within the CNS.
- **Option D:** Associative neurons is another term for interneurons within the brain and spinal cord.

Question #47 Key: (C)BIOLOGY
13. Chemical Coordination

Hormones are biologically defined as:

CORE CONCEPT & DERIVATION

Hormones are regulatory chemical signaling molecules synthesized by endocrine glands, released into extracellular fluids or the bloodstream, and delivered to target tissues to alter cellular function.

Formula / Rule / Reaction:

Endocrine Cell $\xrightarrow{\text{Hormone (Chemical Signal)}}$ Bloodstream → Target Cell Receptor → Physiological Re

Solution:

- Because they coordinate physiological processes via specific chemical structures that bind target receptors, hormones are designated as chemical messengers.

Why other options are incorrect:

- **Option A:** Genetic messengers refer to nucleic acids (mRNA), which carry coding sequences from DNA to ribosomes.
- **Option B:** Hormones are molecular compounds, not physical forces or mechanical agents.
- **Option D:** Biological catalysts are enzymes, which lower activation energy without acting as circulating endocrine signals.

Question #48 Key: (A)BIOLOGY
13. Chemical Coordination

Which lobe of the pituitary gland produces and secretes tropic hormones that control multiple o...

CORE CONCEPT & DERIVATION

The anterior lobe of the pituitary gland (adenohypophysis) synthesizes and secretes major tropic hormones (such as TSH, ACTH, FSH, and LH) that stimulate other target endocrine glands throughout the body.

Formula / Rule / Reaction:

Anterior Pituitary $\xrightarrow{\text{TSH, ACTH, LH, FSH}}$ Thyroid, Adrenal Cortex, and Gonads

Solution:

- Because its secretions regulate thyroid, adrenocortical, and gonadal activity, the anterior pituitary is classically referred to as the master gland of the endocrine system.

Why other options are incorrect:

- **Option B:** The posterior lobe (neurohypophysis) does not synthesize hormones; it stores and releases oxytocin and ADH made in the hypothalamus.
- **Option C:** The intermediate lobe secretes melanocyte-stimulating hormone (MSH) and is largely vestigial in adult humans.
- **Option D:** 'Anterior-posterior lobe' is an incorrect anatomical hybrid term.

Question #49 Key: (C)BIOLOGY
13. Chemical Coordination

Which hormone acts directly on target tissues to lower blood glucose levels?

CORE CONCEPT & DERIVATION

Insulin is a peptide hormone secreted by the beta cells of pancreatic islets of Langerhans that promotes cellular glucose uptake and storage.

Formula / Rule / Reaction:Insulin $\rightarrow$ GLUT-4 Translocation $\rightarrow$ $\uparrow$ Glucose Uptake + $\uparrow$ Glycogenesis $\Rightarrow$ $\downarrow$ Blood Glucose**Solution:**

- Insulin facilitates the movement of glucose into skeletal muscle and adipose tissue and stimulates glycogen synthesis in the liver.
- These actions reduce circulating blood glucose back toward normal homeostatic levels.

Why other options are incorrect:

- Option A:** Glucagon stimulates glycogenolysis and gluconeogenesis, raising blood glucose levels.
- Option B:** Cortisol stimulates gluconeogenesis and exerts anti-insulin effects, raising blood glucose.
- Option D:** Epinephrine stimulates rapid glycogenolysis in the liver and muscle, elevating blood glucose during acute stress.

Question #50 Key: (D)BIOLOGY
15. Inheritance / Variation & GeneticsIf a homozygous white-eyed female *Drosophila* is crossed with a wild-type red-eyed male, what is...**CORE CONCEPT & DERIVATION**In *Drosophila melanogaster*, eye color is an X-linked trait where the wild-type red eye allele (X^w+ or X^R) is dominant to the white eye allele (X^w or X^r).**Formula / Rule / Reaction:**Cross: $X^w X^w$ (White Female) $\times$ $X^+ Y$ (Red Male)Offspring: $X^+ X^w$ (Red Females), $X^w Y$ (White Males)**Solution:**

- The male parent contributes a Y chromosome to all male progeny.
- The female parent contributes an X^w chromosome to all progeny.
- Consequently, all male offspring inherit the genotype $X^w Y$ and express white eyes, giving a probability of 100% (1.0).

Why other options are incorrect:

- Option A:** 0% describes the probability of white eyes among the female offspring, all of which inherit X^+ and have red eyes.
- Option B:** 25% does not reflect this sex-linked cross.
- Option C:** 50% would occur in a cross between a heterozygous female ($X^+ X^w$) and a male.

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

Who coined and originally used the evolutionary phrase 'survival of the fittest'?

CORE CONCEPT & DERIVATIONThe phrase 'survival of the fittest' was coined by English philosopher Herbert Spencer in his 1864 book *Principles of Biology* after reading Charles Darwin's *On the Origin of Species*.**Formula / Rule / Reaction:**

Factual recall / Qualitative concept.

Solution:

- Herbert Spencer devised the term to draw parallels between his economic theories and Darwin's biological mechanism of natural selection.
- Charles Darwin later adopted Spencer's phrase in the fifth edition of *On the Origin of Species* published in 1869.

Why other options are incorrect:

- Option A:** Jean-Baptiste Lamarck proposed the inheritance of acquired characteristics, not survival of the fittest.
- Option B:** Charles Darwin established the mechanism of natural selection but did not originate the phrase.
- Option D:** Aristotle proposed the scala naturae (ladder of nature), predating evolutionary theory.

Question #52 Key: (D)BIOLOGY
16. Evolution

The raw material that is acted upon by natural selection to enable evolutionary adaptation is/a...

CORE CONCEPT & DERIVATION

In modern neo-Darwinian synthesis, mutations generate novel genetic alleles, and genetic variations provide the phenotypic diversity upon which natural selection operates.

Formula / Rule / Reaction:Mutation $\xrightarrow{\text{Origin of Novelty}}$ Genetic Variation $\xrightarrow{\text{Differential Reproduction}}$ Natural Selection**Solution:**

- Mutations represent the ultimate source of all new genetic diversity.
- Chromosomal variations, crossing over, and random assortment assemble these mutations into variable phenotypes, providing the raw material for differential survival.

Why other options are incorrect:

- Option A:** Genetic variation alone is insufficient because without ongoing mutations, populations would eventually exhaust selectable differences.
- Option B:** Mutation alone without chromosomal recombination and phenotypic variation does not account for the full spectrum of selectable traits.
- Option C:** Genetic similarity reflects conservation, which provides no differential basis for selection.

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

Archaeopteryx is a renowned transitional fossil that possesses anatomical characteristics of both...

CORE CONCEPT & DERIVATION

Transitional fossils exhibit ancestral traits of an older lineage alongside derived characteristics of a newer descendant group.

Formula / Rule / Reaction:

Archaeopteryx = Reptilian Traits (Teeth, Long Bony Tail, Claws) + Avian Traits (Feathers, Wings, Furcula)

Solution:

- Discovered in Jurassic limestone in Solnhofen, Germany, *Archaeopteryx* possesses reptilian features such as jaw teeth, clawed digits, and a long bony tail.
- Simultaneously, it displays avian flight feathers, contoured wings, and a wishbone (furcula), documenting the evolutionary transition from theropod reptiles to modern birds.

Why other options are incorrect:

- Option A:** *Tiktaalik* and *Acanthostega* bridge fishes and amphibians.
- Option B:** *Seymouria* represents the transition between amphibians and reptiles.
- Option D:** Cynodonts (such as *Thrinaxodon*) represent the transition between reptiles and mammals.

Question #54 Key: (A)BIOLOGY
16. Evolution

Who proposed the evolutionary concept that an organism can pass modifications acquired during its lifetime...

CORE CONCEPT & DERIVATION

Jean-Baptiste Lamarck formulated the theory of transformation in 1809, postulating that physiological alterations acquired through environmental use or disuse are transmitted to progeny.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Lamarck proposed that changes in an animal's anatomical structures acquired over a lifetime (e.g., the stretching of a giraffe's neck) are directly inherited by its offspring.
- This hypothesis was later refuted by August Weismann's germplasm theory.

Why other options are incorrect:

- Option B:** Charles Darwin proposed natural selection operating on preexisting, inherited variations rather than acquired traits.
- Option C:** Thomas Malthus was an economist whose essays on population dynamics influenced Darwin and Wallace.
- Option D:** Aristotle classified organisms along a fixed, unchanging ladder of nature.

Question #55 Key: (A)BIOLOGY
08. Immunity

Cytotoxic T-lymphocytes (CD8+ T-cells) primarily defend the body by:

CORE CONCEPT & DERIVATION

Cytotoxic T-cells are effector lymphocytes of the cell-mediated immune system specialized to destroy virus-infected, intracellularly parasitized, and neoplastic host cells.

Formula / Rule / Reaction:

Effector CD8⁺ T-Cell $\xrightarrow{\text{MHC-I Recognition}}$ Release of Perforins and Granzymes $\rightarrow$ Apoptotic Lysis

Solution:

- Cytotoxic T-cells recognize foreign antigens presented on cell surfaces bound to MHC Class I molecules.
- Upon activation, they release perforin to form transmembrane pores and granzymes to trigger programmed cell death (apoptosis) in target cells.

Why other options are incorrect:

- Option B:** Helper T-cells (CD4+ T-cells) assist B-cells via cytokine secretion.
- Option C:** B-lymphocytes differentiate into antibody-secreting plasma cells.
- Option D:** Regulatory T-cells (Tregs) suppress immune responses and prevent autoimmunity.

Question #56 Key: (D)BIOLOGY
05. Acellular Life

A bacterial cell with a single flagellum located at one pole is classified morphologically as:

CORE CONCEPT & DERIVATION

Bacteria are classified according to flagellar arrangement into atrichous, monotrichous, lophotrichous, amphitrichous, and peritrichous forms.

Formula / Rule / Reaction:

Monotrichous = 1 Flagellum at One Pole (e.g., *Vibrio cholerae*)

Solution:

- The prefix 'mono-' means single, and 'trichous' denotes hair or flagellum.
- A single flagellum stationed at one end of the bacterium defines a monotrichous arrangement.

Why other options are incorrect:

- Option A:** Amphitrichous bacteria have a single flagellum or tuft of flagella at both opposite poles.
- Option B:** Atrichous bacteria completely lack flagella.
- Option C:** Lophotrichous bacteria have a tuft or cluster of flagella at one pole.

Question #57 Key: (C)BIOLOGY
05. Acellular Life

The genetic material of the Human Immunodeficiency Virus (HIV) consists of:

CORE CONCEPT & DERIVATION

HIV is an enveloped lentivirus belonging to the Retroviridae family, possessing an RNA genome that is reverse-transcribed into DNA within the host cell.

Formula / Rule / Reaction:

HIV Genome = 2 Identical Copies of Single-Stranded Positive-Sense RNA (+ssRNA)

Solution:

- The viral core contains two identical single-stranded RNA molecules associated with reverse transcriptase, integrase, and protease enzymes.

Why other options are incorrect:

- Option A:** cDNA is an intermediate formed inside the host cell by viral reverse transcriptase, not the packaged viral genome.
- Option B:** Retroviruses do not package double-stranded DNA into virions.
- Option D:** rRNA forms part of cellular ribosomes and does not serve as viral genetic material.

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

The human hip joint and shoulder joint are anatomical examples of:

CORE CONCEPT & DERIVATION

A ball and socket joint is a multiaxial synovial joint where the spherical head of one bone fits into the cup-like cavity of another, permitting motion in all planes.

Formula / Rule / Reaction:

Ball and Socket Joint = Spherical Head + Concave Cup $\Rightarrow$ Multiaxial Movement

Solution:

- The shoulder (glenohumeral) joint and hip (acetabulofemoral) joint permit flexion, extension, abduction, adduction, circumduction, and rotation.
- They represent the classic ball and socket synovial joints of the human skeleton.

Why other options are incorrect:

- Option A:** Cartilaginous joints are joined by cartilage and allow limited motion (e.g., pubic symphysis).
- Option B:** Fibrous joints connect bones without a cavity and permit no motion (e.g., cranial sutures).
- Option C:** Hinge joints restrict motion to a single plane (e.g., elbow and knee).

Question #59 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics

The specific physical position occupied by a gene on a chromosome is termed its:

CORE CONCEPT & DERIVATION

In genetics, each gene has a fixed, invariant physical coordinate along the linear sequence of a chromosome called its genetic locus (plural: loci).

Formula / Rule / Reaction:

Locus = Specific Chromosomal Address of an Allele

Solution:

- Homologous chromosomes carry identical or alternative alleles of a given gene at identical loci.
- The question stem asks for the meaning of this position, which is the definition of a locus.

Why other options are incorrect:

- Option B:** Function refers to the biological activity or phenotypic consequence of the encoded protein.
- Option C:** Start point refers to the promoter sequence or initiation codon (AUG) in molecular transcription.
- Option D:** End point refers to transcription terminators or stop codons (UAA, UAG, UGA).

Question #60 Key: (A)BIOLOGY
04. Bioenergetics

Carotenoid accessory pigments primarily absorb light in which region of the visible spectrum?

CORE CONCEPT & DERIVATION

Carotenoids are lipid accessory pigments in photosynthetic membranes that absorb photons in the blue-violet region and transmit yellow, orange, and red wavelengths.

Formula / Rule / Reaction:

$\lambda_{\text{absorption (Carotenoids)}} \approx 400 \text{ to } 500 \text{ nm (Blue-Violet Band)}$

Solution:

- Carotenoids absorb strongly in the range of 400 to 500 nm (specifically peaking at 430 to 480 nm).
- They reflect and transmit longer wavelengths, imparting red, orange, and yellow hues to plant tissues.
- Past Paper Note:** The official provincial paper keyed Option C aberrant to standard photobiology texts. Scientifically, carotenoids absorb blue-violet light (400 to 500 nm) and have virtually zero absorption in the red band (620 to 700 nm). Option A is the scientifically accurate key.

Why other options are incorrect:

- Option B:** 530 to 700 nm spans green, yellow, orange, and red, which carotenoids reflect rather than absorb.
- Option C:** 620 to 700 nm corresponds to the red band, which is absorbed by chlorophyll a, not carotenoids.
- Option D:** 500 to 600 nm covers green and yellow light, which carotenoids do not maximally absorb.

Question #61 Key: (B)BIOLOGY
01. Cell

The inner epithelial cells lining the endoderm (gastrodermis) of Coelenterates are primarily sp...

CORE CONCEPT & DERIVATION

Coelenterates (Cnidarians) possess a diploblastic body wall where the inner gastrodermis lines the gastrovascular coelenteron and carries out extracellular and intracellular digestion.

Formula / Rule / Reaction:

Gastrodermis = Nutritive-Muscular Cells (Intracellular Digestion) + Gland Cells (Enzyme Secretion)

Solution:

- Gland cells of the gastrodermis secrete proteolytic enzymes into the gastrovascular cavity for extracellular digestion.
- Nutritive-muscular cells engulf smaller food particles via phagocytosis to complete intracellular digestion.

Why other options are incorrect:

- Option A:** Nitrogenous waste excretion occurs by simple diffusion across the general body surface.
- Option C:** Defense is mediated by cnidocytes (stinging cells) located primarily in the outer epidermis.
- Option D:** Respiration occurs by direct diffusion of dissolved gases across all exposed cell surfaces.

Question #62 Key: (C)BIOLOGY
05. Acellular Life

Viruses are not classified on the basis of which of the following characteristics?

CORE CONCEPT & DERIVATION

Viruses are acellular biological entities that lack a true cellular membrane, cytoplasm, and intrinsic cellular architecture.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Because viruses are non-cellular, they possess no intrinsic cell membrane.
- Therefore, a cell membrane cannot serve as a parameter for viral taxonomy.

Why other options are incorrect:

- Option A:** Viruses are classified by capsid symmetry (helical, icosahedral, or complex).
- Option B:** Host tropism (bacteriophages, plant viruses, animal viruses) is a classic taxonomic criterion.
- Option D:** The presence or absence of an outer lipid envelope divides viruses into enveloped and non-enveloped (naked) groups.

Question #63 Key: (A)BIOLOGY
01. Cell

An additional protective covering surrounding the cell wall of certain pathogenic bacteria that...

CORE CONCEPT & DERIVATION

The bacterial capsule is a structured, gelatinous outer layer firmly attached to the cell wall that serves as an essential virulence factor by resisting phagocytic engulfment.

Formula / Rule / Reaction:

Bacterial Capsule = Organized Polysaccharide/Polypeptide Layer $\Rightarrow$ Anti-phagocytic Virul

Solution:

- The capsule masks bacterial surface antigens from host antibodies and prevents phagocytosis by macrophages and neutrophils.
- It also promotes surface adherence and biofilm development.

Why other options are incorrect:

- Option B:** The slime layer is loosely bound, diffuse, and easily washed away, unlike a distinct capsule.
- Option C:** The cell membrane lies interior to the cell wall and is not an external covering.
- Option D:** An endospore is an internal dormant survival structure formed under adverse nutritional conditions.

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

The protective protein shell that encloses the viral nucleic acid genome is called the:

CORE CONCEPT & DERIVATION

A virion consists of an inner nucleic acid core enclosed by a protective outer protein coat known as a capsid.

Formula / Rule / Reaction:

Nucleocapsid = Viral Genome (DNA or RNA) + Capsid (Capsomers)

Solution:

- The capsid is composed of repeating protein subunits called capsomers.
- It protects the viral genome from environmental nuclease enzymes and facilitates attachment to host cell receptors.

Why other options are incorrect:

- Option B:** The contractile sheath is an anatomical component of complex myovirus tails (e.g., T4 phage).
- Option C:** A bacteriophage is an entire virus that infects bacterial cells.
- Option D:** A viroid is an infectious agent consisting solely of naked, circular single-stranded RNA without a protein coat.

Question #65 Key: (B)BIOLOGY
04. Bioenergetics

In the non-cyclic electron transport (Z-scheme) of the photosynthetic light reactions, an absorber...

CORE CONCEPT & DERIVATION

In non-cyclic photophosphorylation, the reaction center P_{680} of Photosystem II is photo-oxidized, ejecting a pair of high-energy electrons that are replaced by the photolysis of water.

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

- During illumination, a pair of electrons ($2e^-$) is energized and ejected from the P_{680} special pair to the primary electron acceptor pheophytin.
- This produces an electron deficit of 2 electrons, which is filled by splitting one molecule of water.

Why other options are incorrect:

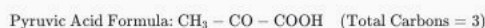
- Option A:** Single-electron transfer steps occur sequentially, but the operational cycle of water oxidation couples pairs of electrons.
- Option C:** Biological photo-oxidation systems operate via pairs or single transfers, not 3 electrons.
- Option D:** 4 electrons correspond to the total yield of splitting two full H_2O molecules to evolve one O_2 .

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

What is the total number of carbon atoms present in one molecule of pyruvic acid (pyruvate)?

CORE CONCEPT & DERIVATION

Glycolysis converts one molecule of 6-carbon glucose into two molecules of the 3-carbon alpha-keto acid known as pyruvic acid.

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

- Pyruvate consists of a methyl carbon ($-CH_3$), a carbonyl keto carbon ($-C=O$), and a carboxyl carbon ($-COOH$).
- Hence, one molecule of pyruvic acid contains exactly 3 carbon atoms.

Why other options are incorrect:

- Option A:** 8 carbons is incorrect; no glycolytic intermediate contains 8 carbons.
- Option B:** 2 carbons is the length of an acetyl group ($-COCH_3$) or acetic acid.
- Option D:** 4 carbons is the length of oxaloacetate or malate in the citric acid cycle.

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

Enzymatic hydrolysis of one molecule of the disaccharide sucrose yields:

CORE CONCEPT & DERIVATION

Sucrose is a non-reducing disaccharide composed of an alpha-D-glucopyranose unit and a beta-D-fructofuranose unit linked by an $\alpha(1 \rightarrow 2)\beta$ glycosidic bond.

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

- Hydrolysis of the glycosidic linkage between carbon-1 of glucose and carbon-2 of fructose by the enzyme sucrase produces equimolar amounts of D-glucose and D-fructose.

Why other options are incorrect:

- Option A:** Lactose is itself a disaccharide, not a cleavage monomer of sucrose.
- Option B:** Lactose is not a monomer product of sucrose hydrolysis.
- Option D:** Glucose and galactose are the products of lactose hydrolysis.

Question #68 Key: (A)BIOLOGY
02. Biomolecules

The quantity of thermal energy required to convert one gram of a liquid into vapour at its norm...

CORE CONCEPT & DERIVATION

Latent heat of vaporization represents the energy absorbed by a substance to break intermolecular attractive forces during the phase transition from liquid to gas at constant boiling temperature.

Formula / Rule / Reaction:

$$Q = m \cdot L_v \implies L_v = \frac{Q}{m} \quad (\text{For water, } L_v \approx 2260 \text{ J/g or } 540 \text{ cal/g})$$

Solution:

- The amount of heat needed to transform a unit mass (one gram) of liquid into vapor at its boiling point is defined as the latent heat of vaporization.
- In water, this value is exceptionally high due to extensive intermolecular hydrogen bonding.

Why other options are incorrect:

- Option B:** Specific heat capacity is the thermal energy needed to raise the temperature of one gram of a substance by 1°C .
- Option C:** Heat of ionization is the enthalpy change accompanying the complete ionization of one mole of a substance in solution.
- Option D:** Polarity is an intrinsic molecular charge property, not a thermodynamic quantity of thermal energy.

Question #69 Key: (A)

CHEMISTRY
01. Stoichiometry

Which of the following contains the same number of molecules as 22 grams of carbon dioxide (CO₂)?

CORE CONCEPT & DERIVATION

According to Avogadro's hypothesis, equal numbers of moles of different substances contain an equal number of chemical molecules.

Formula / Rule / Reaction:

$$n = \frac{\text{Mass}}{\text{Molar Mass}}, \quad N = n \cdot N_A$$

Solution:

- Molar mass of CO₂ = 12 + (2 × 16) = 44 g/mol.
- Moles of CO₂ = $\frac{22 \text{ g}}{44 \text{ g/mol}} = 0.5 \text{ mol}$.
- Calculate the moles for each candidate:
- For 9 g of H₂O: $n = \frac{9}{18} = 0.5 \text{ mol}$. Because $n = 0.5 \text{ mol}$, it contains exactly $0.5 N_A$ molecules.

Why other options are incorrect:

- **Option B:** 2 g of H₂ = $\frac{2}{2} = 1.0 \text{ mol}$ (twice the number of molecules).
- **Option C:** 32 g of O₂ = $\frac{32}{32} = 1.0 \text{ mol}$.
- **Option D:** 71 g of Cl₂ = $\frac{71}{71} = 1.0 \text{ mol}$.

Question #70 Key: (B)

CHEMISTRY
01. Stoichiometry

The molecular mass of an organic compound is 60, and its empirical formula is CH₂O. What is the molecular formula?

CORE CONCEPT & DERIVATION

The molecular formula is an integer multiple of the empirical formula determined by the ratio of molecular mass to empirical formula mass.

Formula / Rule / Reaction:

$$n = \frac{\text{Molecular Mass}}{\text{Empirical Formula Mass}}, \quad \text{Molecular Formula} = (\text{Empirical Formula})_n$$

Solution:

- Empirical formula mass of CH₂O = 12 + (2 × 1) + 16 = 30 g/mol.
- Integer multiple: $n = \frac{60}{30} = 2$.
- Molecular formula = (CH₂O)₂ = C₂H₄O₂ (acetic acid).

Why other options are incorrect:

- **Option A:** C₆H₁₂O₆ has a molecular mass of 180, corresponding to $n = 6$.
- **Option C:** C₂H₆O₂ has a molecular mass of 62 and an empirical formula of CH₃O.
- **Option D:** C₂H₄O₂ has an empirical formula of CH₂O and invalid valency.

Question #71 Key: (B)

CHEMISTRY
02. Atomic Structure

According to Planck's quantum theory, the greater the wavelength (λ) associated with light, the lower the energy of the photon.

CORE CONCEPT & DERIVATION

The energy of an electromagnetic photon is directly proportional to its frequency and inversely proportional to its wavelength.

Formula / Rule / Reaction:

$$E = h\nu = \frac{hc}{\lambda} \implies E \propto \frac{1}{\lambda}$$

Solution:

- As the wavelength (λ) of a photon increases, the denominator in Planck's equation increases.
- Consequently, the quantum energy (E) carried by that individual photon decreases proportionately.

Why other options are incorrect:

- **Option A:** Energy increases with decreasing wavelength (increasing frequency), not increasing wavelength.
- **Option C:** Photon energy is strictly quantized in discrete packets according to $E = h\nu$.
- **Option D:** Photon energy varies across the electromagnetic spectrum depending on wavelength.

Question #72 Key: (A)

CHEMISTRY
03. Chemical Bonding

Identify the compound in which the chemical bonds are formed by the overlapping of p-orbitals.

CORE CONCEPT & DERIVATION

Orbital hybridization of the central atom determines the geometry and overlapping atomic orbital sets that form covalent bonds.

Formula / Rule / Reaction:

In BeCl₂: Central Be is sp-hybridized; Cl provides an unhybridized singly-occupied 3p_z orbital.

Solution:

- Beryllium in BeCl₂ forms two linear sigma bonds using two equivalent sp hybrid orbitals.
- Each chlorine atom has an electron configuration of [Ne] 3s² 3p² 3p_y² 3p_z² and uses its half-filled 3p orbital for bonding.
- The resulting Be – Cl bonds are formed by the overlap of sp (from Be) and p (from Cl) orbitals.

Why other options are incorrect:

- **Option B:** In BF₃, bonding involves sp² hybrid orbitals of boron overlapping with 2p orbitals of fluorine.
- **Option C:** In H₂O, bonding involves sp³ hybrid orbitals of oxygen overlapping with the 1s orbital of hydrogen.
- **Option D:** In NH₃, bonding involves sp³ hybrid orbitals of nitrogen overlapping with the 1s orbital of hydrogen.

Question #73 Key: (C)

CHEMISTRY
03. Chemical Bonding

Which of the following second-period elements has the highest first ionization energy?

CORE CONCEPT & DERIVATION

Ionization energy generally increases across a period from left to right, but subshells that are completely filled or half-filled exhibit extra quantum stability, producing anomalies in the trend.

Formula / Rule / Reaction:



Solution:

- Nitrogen possesses a stable half-filled $2p^3$ subshell, which requires extra energy to disrupt.
- Oxygen has four $2p$ electrons, where electron-electron repulsion between paired electrons in the $2p_x$ orbital makes the first electron easier to remove than in nitrogen.
- First ionization energies: N = 1402 kJ/mol, O = 1314 kJ/mol, C = 1086 kJ/mol, and Be = 899 kJ/mol.

Why other options are incorrect:

- Option A:** Oxygen has a lower ionization energy than nitrogen due to spin-pairing repulsion in the $2p$ subshell.
- Option B:** Carbon has a lower effective nuclear charge and a lower ionization energy (1086 kJ/mol).
- Option D:** Beryllium lies to the left of these elements and has a lower effective nuclear charge (899 kJ/mol).

Question #74 Key: (A)

CHEMISTRY
04. Gases

Which of the following real gases shows the most marked deviation from ideal gas behavior under...

CORE CONCEPT & DERIVATION

Real gases deviate from ideality because of finite molecular volumes and intermolecular attractive forces; gases with greater molecular masses and higher polarizabilities exhibit the largest deviations.

Formula / Rule / Reaction:

$$\left(P + \frac{n^2 a}{V^2}\right)(V - nb) = nRT \quad (\text{Larger Van der Waals constant } a \Rightarrow \text{Greater Deviation})$$

Solution:

- CO_2 is the largest and most polarizable molecule among the choices, possessing the strongest London dispersion forces and the largest Van der Waals constants.
- Consequently, CO_2 exhibits the greatest compressibility factor deviation ($Z \neq 1$) compared to light gases like He and H_2 .

Why other options are incorrect:

- Option B:** Helium has an exceptionally small atomic size and negligible dispersion forces, behaving almost ideally.
- Option C:** H_2 has a very low mass and minimal intermolecular attraction, remaining close to ideal behavior.
- Option D:** N_2 is non-polar with lower molecular weight and smaller Van der Waals constants than CO_2 .

Question #75 Key: (C)

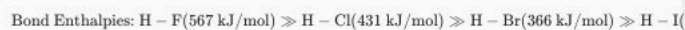
CHEMISTRY
05. Liquids

The exceptionally low acidic strength of hydrofluoric acid ([Formula]) compared to other hydr...

CORE CONCEPT & DERIVATION

Acidic strength of binary halogen hydrides depends on the H – X bond dissociation energy and the stabilization of dissociated ions in aqueous solution.

Formula / Rule / Reaction:



Solution:

- HF features a very short bond length, yielding an exceptionally high bond dissociation enthalpy (567 kJ/mol) that strongly opposes heterolytic cleavage.
- In aqueous solution, extensive hydrogen bonding forms tight ion-pair clusters $[\text{H}_3\text{O}^+ \cdot \text{F}^-]$, which traps hydronium ions and suppresses free proton release.
- Thus, HF acts as a weak acid, unlike HCl, HBr, and HI.

Why other options are incorrect:

- Option A:** Bond polarity alone would favor heterolysis; polarity by itself does not explain why HF is weak while less-polar HI is very strong.
- Option B:** Small size contributes to high bond enthalpy, but it is the resulting bond strength and hydrogen bonding that directly govern dissociation.
- Option D:** High electronegativity increases bond polarity, which usually promotes acid dissociation in oxoacids.

Question #76 Key: (C)

CHEMISTRY
05. Liquids

Which of the following compounds has the lowest normal boiling point?

CORE CONCEPT & DERIVATION

The boiling point of a covalent molecular substance depends on the strength of its intermolecular forces (hydrogen bonding versus dipole-dipole or London dispersion forces).

Formula / Rule / Reaction:



Solution:

- Water, ethanol, and acetic acid all feature intermolecular hydrogen bonding.
- Sulfur has a lower electronegativity than oxygen, so H_2S cannot form strong hydrogen bonds and is held together only by weak dipole-dipole and London forces.
- As a result, H_2S is a gas at room temperature with a boiling point of -60°C .

Why other options are incorrect:

- Option A:** Water has extensive three-dimensional hydrogen bonding and boils at 100°C .
- Option B:** Ethanol forms hydrogen-bonded networks and boils at 78.3°C .
- Option D:** Acetic acid forms stable hydrogen-bonded dimers in the liquid phase and boils at 118°C .

Question #77 Key: (C)

CHEMISTRY
05. Liquids

A domestic pressure cooker significantly reduces the time required to cook food because:

CORE CONCEPT & DERIVATION

The boiling point of a liquid is the temperature at which its vapor pressure equals the external atmospheric pressure.

Formula / Rule / Reaction:

$$P_{\text{ext}} \uparrow \Rightarrow T_{\text{boiling}} \uparrow \Rightarrow \text{Rate of Cooking Reactions} \uparrow$$

Solution:

- Inside a sealed pressure cooker, water vapor accumulates, increasing the internal pressure up to roughly 2 atm.
- Under this elevated pressure, water boils at approximately 120°C instead of 100°C.
- Because chemical cooking reactions proceed faster at higher temperatures, cooking time is substantially reduced.

Why other options are incorrect:

- Option A:** Trapping heat without raising the cooking temperature would not accelerate chemical tenderization.
- Option B:** Even heat distribution avoids hot spots, but it does not account for the marked increase in cooking rate.
- Option D:** Food is softened by thermal denaturation of proteins and hydrolysis of starch at high temperature, not by mechanical pressure.

Question #78 Key: (A)

CHEMISTRY
06. Solids

Which of the following ionic compounds has the highest value of lattice energy?

CORE CONCEPT & DERIVATION

According to Coulomb's law, lattice energy is directly proportional to the product of ionic charges and inversely proportional to the sum of the ionic radii (interionic distance).

Formula / Rule / Reaction:

$$U \propto \frac{|z^+ \cdot z^-|}{r_+ + r_-}$$

Solution:

- All four compounds are composed of monovalent cations and anions ($|z^+ \cdot z^-| = 1$).
- Lattice energy therefore depends on interionic distance: smaller ions produce higher lattice energies.
- Comparing interionic distances: NaF ($r_{\text{Na}^+} + r_{\text{F}^-} = 102 + 133 = 235 \text{ pm}$), LiCl ($76 + 181 = 257 \text{ pm}$).
- Standard experimental values confirm $\text{NaF} = 923 \text{ kJ/mol}$, whereas $\text{LiCl} = 853 \text{ kJ/mol}$, $\text{NaI} = 705 \text{ kJ/mol}$, and $\text{KI} = 649 \text{ kJ/mol}$. Hence, NaF has the highest lattice energy.

Why other options are incorrect:

- Option B:** LiCl has a larger interionic distance than NaF due to the large chloride ion (181 pm), giving it a lower lattice energy.
- Option C:** NaI has a large iodide ion (220 pm), resulting in a lower lattice energy.
- Option D:** KI contains both a large cation and a large anion, giving it the lowest lattice energy of the group.

Question #79 Key: (A)

CHEMISTRY
06. Solids

Which of the following is classified as a polar molecular crystalline solid?

CORE CONCEPT & DERIVATION

Molecular crystalline solids consist of discrete molecules held together by intermolecular forces; they are subdivided into polar and non-polar molecular solids based on bond dipoles.

Formula / Rule / Reaction:

Polar Molecular Solid: Discrete Molecules with Permanent Dipoles held by Dipole-Dipole / H-E

Solution:

- Ice consists of discrete H_2O molecules held in an open cage-like lattice by polar, directional hydrogen bonds.
- Because H_2O has a permanent dipole moment ($\mu = 1.85 \text{ D}$), ice is classified as a polar molecular solid.

Why other options are incorrect:

- Option B:** Iodine (I_2) is a non-polar molecular solid held only by London dispersion forces.
- Option C:** Copper is a metallic crystalline solid with metallic bonding.
- Option D:** White phosphorus (P_4) consists of non-polar tetrahedral units held by dispersion forces.

Question #80 Key: (A)

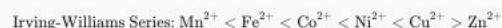
CHEMISTRY
12. Transition Elements

Which of the following divalent transition metal ions typically forms the most thermodynamically...

CORE CONCEPT & DERIVATION

The thermodynamic stability of high-spin divalent first-row transition metal complexes follows the Irving-Williams stability series.

Formula / Rule / Reaction:



Solution:

- Across the first transition series, effective nuclear charge increases and ionic radius decreases, reaching an ionic charge-density maximum at Cu^{2+} .
- Furthermore, $d^9 \text{Cu}^{2+}$ complexes undergo Jahn-Teller distortion, providing additional electronic stabilization.
- Therefore, Cu^{2+} forms the most stable coordination complexes among these divalent ions.

Why other options are incorrect:

- Option B:** Ni^{2+} complexes are less stable than Cu^{2+} according to the Irving-Williams series.
- Option C:** Fe^{2+} has a larger ionic radius and lower charge density than Cu^{2+} .
- Option D:** Mn^{2+} has a stable half-filled d^5 configuration with zero ligand-field stabilization energy in high-spin complexes, giving it the lowest stability of the group.

Question #81 Key: (A)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

All of the following chemical compounds are classified as organic except:

CORE CONCEPT & DERIVATION

Organic compounds contain carbon covalently bonded to hydrogen (or other heteroatoms in hydrocarbon derivatives); simple carbonates, cyanates, and cyanides of metals are classified as inorganic salts.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Potassium cyanate (KOCN) is an ionic salt composed of K^+ and cyanate $[OCN]^-$ ions, lacking carbon-hydrogen bonds.
- Consequently, it is classified as an inorganic compound.

Why other options are incorrect:

- Option B:** Phenol (C_6H_5OH) is an aromatic organic compound.
- Option C:** Methyl acetate (CH_3COOCH_3) is an organic ester.
- Option D:** Methanol (CH_3OH) is a simple organic alcohol.

Question #82 Key: (A)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Structural or stereochemical isomers of a chemical substance must always possess the same:

CORE CONCEPT & DERIVATION

Isomers are compounds that share an identical molecular formula but differ in the connectivity or spatial arrangement of their constituent atoms.

Formula / Rule / Reaction:



Solution:

- Because isomers have the exact same number and types of atoms, their calculated molecular mass must always be identical.
- Their physical properties, chemical reactivity, and structural arrangements can differ significantly.

Why other options are incorrect:

- Option B:** Functional group isomers (e.g., ethanol vs. dimethyl ether) display different chemical properties.
- Option C:** Structural isomers differ in connectivity, so their structural formulas are not the same.
- Option D:** Functional isomers contain different functional groups (e.g., aldehydes vs. ketones).

Question #83 Key: (B)

CHEMISTRY
05. Liquids

Which of the following cycloalkanes possesses the highest normal boiling point?

CORE CONCEPT & DERIVATION

In homologous series of non-polar hydrocarbons, the boiling point increases with increasing molecular mass and surface area because of stronger London dispersion forces.

Formula / Rule / Reaction:

Boiling Points: Cycloheptane (118.8°C) > Cyclohexane (80.7°C) > Cyclopentane (49.2°C) > Cyclobutane (12.5°C)

Solution:

- Cycloheptane (C_7H_{14}) has seven ring carbons, giving it the largest molecular weight and greatest polarizable surface area among the options.
- Its stronger London dispersion forces require more thermal energy to overcome, resulting in the highest boiling point (118.8°C).

Why other options are incorrect:

- Option A:** Cyclohexane (C_6H_{12}) has a lower boiling point (80.7°C).
- Option C:** Cyclopentane (C_5H_{10}) boils at 49.2°C .
- Option D:** Cyclobutane (C_4H_8) has the lowest molecular mass in this group and boils at 12.5°C .

Question #84 Key: (A)

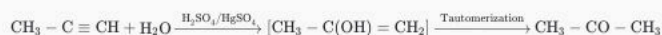
CHEMISTRY
14. Hydrocarbons

Propyne reacts with aqueous sulfuric acid in the presence of mercuric sulfate ([Formula]) cat...

CORE CONCEPT & DERIVATION

Hydration of alkynes follows Markovnikov's rule to yield an unstable enol intermediate, which undergoes keto-enol tautomerization to form a carbonyl compound.

Formula / Rule / Reaction:



Solution:

- Electrophilic addition of water to propyne directs the hydroxyl group ($-OH$) to the more substituted internal carbon (C-2), following Markovnikov's rule.
- The resulting enol intermediate (prop-1-en-2-ol) rapidly tautomerizes into its more stable keto form: acetone (propan-2-one).

Why other options are incorrect:

- Option B:** 1-propanol is an alcohol prepared by hydroboration-oxidation of propene, not hydration of propyne.
- Option C:** 2-propanol is produced by hydrating propene, an alkene.
- Option D:** Acetaldehyde is the unique alkyne hydration product formed only from ethyne (acetylene).

Question #85 Key: (A)

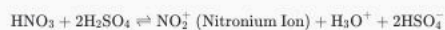
CHEMISTRY
14. Hydrocarbons

The active electrophile responsible for the electrophilic aromatic substitution in the nitration...

CORE CONCEPT & DERIVATION

In aromatic nitration using a mixture of concentrated HNO_3 and concentrated H_2SO_4 , sulfuric acid acts as a Bronsted acid to protonate nitric acid, generating the nitronium ion.

Formula / Rule / Reaction:



Solution:

- The nitronium ion (NO_2^+) is a strong linear electrophile.
- It attacks the electron-rich pi cloud of benzene to form an arenium ion (Wheland intermediate), which loses a proton to regenerate aromaticity and yield nitrobenzene.

Why other options are incorrect:

- Option B:** NO_2^- is the nitrite anion, which is a nucleophile and is repelled by the electron-rich benzene ring.
- Option C:** NO^+ is the nitrosonium ion, which acts as the electrophile in diazotization, not nitration.
- Option D:** HNO_2^+ is a transient species that rapidly loses water to form NO_2^+ .

Question #86 Key: (A)

CHEMISTRY
14. Hydrocarbons

Which of the following alkyl halides will undergo the fastest [Formula] nucleophilic substituti...

CORE CONCEPT & DERIVATION

The $\text{S}_{\text{N}}2$ mechanism involves a concerted backside attack by the nucleophile, and its reaction rate is governed primarily by steric hindrance at the alpha carbon.

Formula / Rule / Reaction:

Reactivity in $\text{S}_{\text{N}}2$: Methyl > 1° > 2° > 3° (Governed by Steric Hindrance)

Solution:

- Methyl bromide (CH_3Br) has three small hydrogen atoms attached to the electrophilic carbon, providing the least steric hindrance for backside attack by hydroxide ion.
- Consequently, it exhibits the lowest activation energy and the fastest rate for an $\text{S}_{\text{N}}2$ substitution.

Why other options are incorrect:

- Option B:** Ethyl bromide is a primary alkyl halide and is more hindered than methyl bromide.
- Option C:** Isopropyl bromide is a secondary alkyl halide that reacts substantially slower via $\text{S}_{\text{N}}2$.
- Option D:** Tert-butyl bromide is a tertiary halide where three methyl groups block backside attack, undergoing $\text{E}2$ elimination or $\text{S}_{\text{N}}1$ substitution instead.

Question #87 Key: (A)

CHEMISTRY
05. Liquids

Which of the following alkyl halides has the highest normal boiling point?

CORE CONCEPT & DERIVATION

The boiling point of alkyl halides increases with greater molecular weight, higher polarizability of the halogen atom ($\text{I} > \text{Br} > \text{Cl} > \text{F}$), and longer, unbranched carbon chains.

Formula / Rule / Reaction:

Boiling Point Factors: Molecular Weight $\uparrow$, Halogen Polarizability (Iodine is Highest), Line

Solution:

- Comparing the options, butyl halides have four carbons, giving them higher molecular weights than propyl halides.
- Iodine is larger and more polarizable than bromine, producing stronger London dispersion forces.
- Between n-butyl iodide and isobutyl iodide, the linear, unbranched n-butyl chain provides a larger surface area and closer intermolecular packing, giving it the highest boiling point (130.5°C).

Why other options are incorrect:

- Option B:** Isobutyl iodide has a branched chain, which reduces surface area and lowers the boiling point to 120°C .
- Option C:** Isopropyl bromide has fewer carbons and a less polarizable bromine atom, boiling at 59°C .
- Option D:** n-propyl bromide contains only three carbons and a bromine atom, boiling at 71°C .

Question #88 Key: (C)

CHEMISTRY
15. Alkyl Halides

Which of the following factors does not affect the rate of an [Formula] nucleophilic substituti...

CORE CONCEPT & DERIVATION

The $\text{S}_{\text{N}}1$ reaction is a two-step substitution whose rate is determined solely by the unimolecular ionization of the substrate to form a carbocation intermediate.

Formula / Rule / Reaction:

$$\text{Rate} = k[\text{Substrate}]^1[\text{Nucleophile}]^0$$

Solution:

- The rate-determining step involves heterolytic cleavage of the carbon-halogen bond: $\text{R}-\text{X} \rightarrow \text{R}^+ + \text{X}^-$.
- Because the nucleophile enters only in the subsequent fast step, its chemical nature and concentration have no effect on the overall reaction rate.

Why other options are incorrect:

- Option A:** Polar protic solvents stabilize the carbocation and leaving group, significantly accelerating $\text{S}_{\text{N}}1$ ionization.
- Option B:** The stability of the carbocation intermediate directly lowers the activation energy of the rate-determining step.
- Option D:** More substituted substrates (tertiary > secondary) form more stable carbocations, markedly increasing the reaction rate.

Question #89 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

Which of the following hydroxyl-containing organic compounds exhibits the lowest acidic strength...

CORE CONCEPT & DERIVATION

The acidity of a compound depends on the stability of the conjugate base formed upon deprotonation; resonance stabilization of negative charge enhances acidity, whereas localized charge reduces it.

Formula / Rule / Reaction:

pK_a Values: p-Nitrophenol (7.15) < p-Chlorophenol (9.38) < Phenol (9.95) $\ll$ Ethanol (15.9)

Solution:

- In phenols, the negative charge of the phenoxide ion is delocalized into the aromatic pi system via resonance.
- In ethanol, deprotonation yields the ethoxide ion ($\text{CH}_3\text{CH}_2\text{O}^-$), where the negative charge is concentrated on the oxygen atom and further destabilized by the electron-donating inductive effect (+I) of the ethyl group.
- With a pK_a of approximately 16, ethanol is the weakest acid among the choices.

Why other options are incorrect:

- Option A:** Phenol is roughly a million times more acidic than ethanol due to resonance stabilization in the phenoxide anion.
- Option B:** p-Nitrophenol has a strong electron-withdrawing nitro group ($-M$, $-I$), making it the most acidic compound in the group.
- Option D:** p-Chlorophenol is more acidic than phenol due to the electron-withdrawing inductive effect ($-I$) of the chlorine atom.

Question #90 Key: (D)

CHEMISTRY
07. Equilibrium

The buffering capacity of an aqueous buffer solution reaches its maximum efficiency when:

CORE CONCEPT & DERIVATION

Buffer capacity (β) is the measure of a solution's resistance to pH changes upon the addition of strong acid or base, governed by the Henderson-Hasselbalch relationship.

Formula / Rule / Reaction:

$$\text{pH} = \text{p}K_a + \log\left(\frac{[\text{A}^-]}{[\text{HA}]}\right); \quad \beta_{\text{max}} \text{ occurs when } [\text{A}^-] = [\text{HA}] \text{ and concentrations are large}$$

Solution:

- A buffer resists pH changes best when the ratio of conjugate acid to conjugate base is equal to 1, meaning $\text{pH} = \text{p}K_a$.
- Furthermore, the total moles of added acid or base that can be neutralized is directly proportional to the absolute concentrations of the buffer components.
- Therefore, high and equal molar concentrations provide maximum buffering capacity.

Why other options are incorrect:

- Option A:** Dilute concentrations result in a low buffer capacity that is quickly exhausted by small additions of acid or base.
- Option B:** While equal concentrations optimize the ratio, low concentrations limit the overall capacity.
- Option C:** A ratio greater than 10 falls outside the optimal buffer range ($\text{p}K_a \pm 1$), causing the buffer to be easily exhausted by added base.

Question #91 Key: (A)

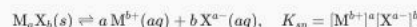
CHEMISTRY
07. Equilibrium

If an ionic salt has a relatively large solubility product constant (K_{sp}) in water at r...

CORE CONCEPT & DERIVATION

The solubility product constant (K_{sp}) is the equilibrium constant for the dissolution of a solid ionic compound into its hydrated ions in a saturated aqueous solution.

Formula / Rule / Reaction:



Solution:

- A larger value of K_{sp} means the dissolution equilibrium lies further to the right.
- For salts with similar stoichiometry, a higher K_{sp} correlates directly with higher molar solubility in water.

Why other options are incorrect:

- Option B:** Lower K_{sp} values indicate lower solubility and a greater tendency to precipitate.
- Option C:** Insoluble and moderately insoluble salts are characterized by very small K_{sp} values (typically 10^{-10} to 10^{-50}).
- Option D:** Truly insoluble salts have negligible, near-zero K_{sp} values.

Question #92 Key: (B)

CHEMISTRY
08. Reaction Kinetics

If the specific rate constant (k) of a chemical reaction has the units [Formula], wh...

CORE CONCEPT & DERIVATION

The dimensional units of the rate constant k depend directly on the overall reaction order n .

Formula / Rule / Reaction:

$$\text{Unit of } k = (\text{Concentration})^{1-n} \cdot \text{time}^{-1} = (\text{mol} \cdot \text{dm}^{-3})^{1-n} \text{s}^{-1}$$

Solution:

- Substitute $n = 2$ into the general dimensional formula:
- $\text{Unit} = (\text{mol} \cdot \text{dm}^{-3})^{1-2} \text{s}^{-1} = (\text{mol} \cdot \text{dm}^{-3})^{-1} \text{s}^{-1} = \text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$.
- Therefore, the reaction is of the second order.

Why other options are incorrect:

- Option A:** For a first-order reaction ($n = 1$), the units are s^{-1} .
- Option C:** For a zero-order reaction ($n = 0$), the units are $\text{mol} \cdot \text{dm}^{-3} \text{s}^{-1}$.
- Option D:** For a third-order reaction ($n = 3$), the units are $\text{dm}^6 \text{mol}^{-2} \text{s}^{-1}$.

Question #93 Key: (C)

CHEMISTRY
09. Thermochemistry

A thermodynamic system that can freely exchange both energy and matter with its surroundings is...

CORE CONCEPT & DERIVATION

Thermodynamic systems are classified by the permeability of their boundaries to energy and matter transfer.

Formula / Rule / Reaction:

$$\text{Open System: } \Delta M \neq 0 \quad \text{and} \quad \Delta E \neq 0$$

Solution:

- An open system has boundaries that allow both matter and energy (in the form of heat and work) to enter or leave.
- A classic example is an open beaker of boiling water.

Why other options are incorrect:

- Option A:** An isolated system permits neither energy nor matter to cross its boundary (e.g., a sealed, rigid thermos flask).
- Option B:** A closed system can exchange energy with its surroundings, but not matter (e.g., a sealed metallic container).
- Option D:** An adiabatic system is insulated against the transfer of heat ($q = 0$), though it may still exchange work.

Question #94 Key: (D)

CHEMISTRY
09. Thermochemistry

The total sum of all translational, rotational, vibrational kinetic energies, and intermolecular...

CORE CONCEPT & DERIVATION

Internal energy (U) is a state function representing the total energy contained within a thermodynamic system at the molecular level.

Formula / Rule / Reaction:

$$U = \sum E_{\text{kinetic}} + \sum E_{\text{potential}}$$

Solution:

- Internal energy includes all microscopic forms of energy: translational, vibrational, and rotational motions of molecules, along with the chemical bonding and intermolecular potential energies between particles.

Why other options are incorrect:

- Option A:** Specific heat is the energy required to raise the temperature of one unit mass of a substance by one degree.
- Option B:** Heat capacity is the thermal energy needed to raise the temperature of an entire body by one degree.
- Option C:** Latent heat is the thermal energy absorbed or released during an isothermal phase transition.

Question #95 Key: (A)

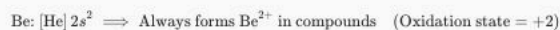
CHEMISTRY
11. S & P Block Elements

Which of the following chemical elements exhibits the same fixed oxidation state in all of its ...

CORE CONCEPT & DERIVATION

Group II-A alkaline earth metals possess two valence electrons in their outermost s subshell, which are lost to attain a noble-gas configuration, resulting exclusively in a +2 oxidation state in compounds.

Formula / Rule / Reaction:



Solution:

- Beryllium (along with the other alkaline earth metals) always exhibits an oxidation state of +2 in all of its stable chemical compounds.
- In contrast, halogens and p-block elements show variable oxidation numbers.

Why other options are incorrect:

- Option B:** Chlorine exhibits variable oxidation states ranging from -1 (e.g., HCl) to $+1$, $+3$, $+5$, and $+7$ (e.g., HClO_4).
- Option C:** Nitrogen shows diverse oxidation states from -3 (in NH_3) to $+5$ (in HNO_3).
- Option D:** Bromine exhibits oxidation states of -1 , $+1$, $+3$, $+5$, and $+7$.

Question #96 Key: (B)

CHEMISTRY
10. Electrochemistry

In any functioning galvanic (voltaic) electrochemical cell, the cathode always has a standard $r...$

CORE CONCEPT & DERIVATION

For a galvanic cell to generate an electric current spontaneously, the overall cell potential must be positive ($E_{\text{cell}}^{\circ} > 0$).

Formula / Rule / Reaction:

$$E_{\text{cell}}^{\circ} = E_{\text{cathode}}^{\circ} - E_{\text{anode}}^{\circ} > 0 \Rightarrow E_{\text{cathode}}^{\circ} > E_{\text{anode}}^{\circ}$$

Solution:

- Reduction takes place at the cathode, which requires the cathode half-cell to have a stronger affinity for electrons than the anode.
- Therefore, the standard reduction potential of the cathode must be more positive (algebraically greater) than that of the anode.

Why other options are incorrect:

- Option A:** If the cathode had a lower reduction potential than the anode, E_{cell}° would be negative, making the cell non-spontaneous (an electrolytic cell).
- Option C:** If both potentials were identical, the net cell potential would be zero and no current would flow.
- Option D:** Zero volts is assigned by convention exclusively to the Standard Hydrogen Electrode (SHE).

Question #97 Key: (D)

CHEMISTRY
11. S & P Block Elements

When an isolated neutral atom gains one or more electrons to form an anion, its radius changes...

CORE CONCEPT & DERIVATION

Adding electrons to form an anion increases electron-electron repulsion within the valence shell and decreases the effective nuclear charge per electron, expanding the electron cloud.

Formula / Rule / Reaction:

$$r_{\text{anion}} > r_{\text{neutral atom}} \quad (\text{e.g., } r_{\text{Cl}} = 99 \text{ pm} \rightarrow r_{\text{Cl}^-} = 181 \text{ pm})$$

Solution:

- When an atom gains an electron, the nuclear charge (number of protons) remains unchanged while the number of valence electrons increases.
- The increased mutual electrostatic repulsion causes the electron cloud to expand outward.
- Consequently, an anion is always larger than its parent neutral atom.

Why other options are incorrect:

- Option A:** Anionic radii are consistently larger than the corresponding covalent radii.
- Option B:** Cations are smaller than their parent atoms, whereas anions are larger.
- Option C:** Adding electrons alters electron shielding, so the ionic radius cannot remain equal to the atomic radius.

Question #98 Key: (A)

CHEMISTRY
12. Transition Elements

What is the elemental chemical composition of the non-ferrous alloy known as German silver?

CORE CONCEPT & DERIVATION

German silver (also known as nickel silver) is a silvery-white alloy named for its visual appearance, but it contains no elemental silver.

Formula / Rule / Reaction:

$$\text{German Silver Composition} \approx 50 \text{ to } 60\% \text{ Cu, } 20\% \text{ Zn, } 20\% \text{ Ni}$$

Solution:

- German silver is an alloy of copper, zinc, and nickel.
- Its silver-white color and corrosion resistance make it useful for tableware, decorative metalwork, and musical instruments.

Why other options are incorrect:

- Option B:** Despite its name, German silver contains no actual elemental silver (Ag).
- Option C:** Cu + Sn + Zn + Pb corresponds to bronze compositions.
- Option D:** Al + Cu + Mg + Mn is the composition of duralumin, a lightweight structural alloy used in aviation.

Question #99 Key: (C)

CHEMISTRY
08. Reaction Kinetics

A first-order chemical reaction proceeds with a rate of [Formula] when the reactant concentration is [A].

CORE CONCEPT & DERIVATION

For a first-order reaction, the differential rate law expresses the reaction rate as directly proportional to the first power of reactant concentration.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^1 \Rightarrow k = \frac{\text{Rate}}{[A]}$$

Solution:

- Given: Rate = $0.6 \text{ mol} \cdot \text{dm}^{-3} \text{ s}^{-1}$ and $[A] = 1.0 \text{ mol} \cdot \text{dm}^{-3}$.
- Substitute into the rate equation:

$$k = \frac{0.6 \text{ mol} \cdot \text{dm}^{-3} \text{ s}^{-1}}{1.0 \text{ mol} \cdot \text{dm}^{-3}} = 0.6 \text{ s}^{-1}$$

Why other options are incorrect:

- Option A:** 1.0 s^{-1} would yield a rate of $1.0 \text{ mol} \cdot \text{dm}^{-3} \text{ s}^{-1}$.
- Option B:** 0.3 s^{-1} would correspond to a rate of $0.3 \text{ mol} \cdot \text{dm}^{-3} \text{ s}^{-1}$.
- Option D:** 0.9 s^{-1} is inconsistent with the given rate and concentration values.

Question #100 Key: (B)

CHEMISTRY
14. Hydrocarbons

What type of reaction mechanism takes place when phenol is treated with dilute nitric acid (F...)?

CORE CONCEPT & DERIVATION

Phenol possesses an electron-rich aromatic ring due to the resonance donation of the lone pair on the hydroxyl oxygen, undergoing electrophilic aromatic substitution under mild conditions.

Formula / Rule / Reaction:



Solution:

- The hydroxyl group activates the benzene ring and directs incoming electrophiles to the ortho and para positions.
- The electrophilic nitronium ion (NO_2^+) attacks the ring, replacing an aromatic proton via an electrophilic aromatic substitution ($\text{S}_{\text{E}}\text{Ar}$) mechanism.

Why other options are incorrect:

- Option A:** Electrophilic addition occurs across isolated carbon-carbon double or triple bonds, not stable aromatic rings.
- Option C:** Nucleophilic substitution requires electron-withdrawing leaving groups and strong nucleophiles, which is not the case here.
- Option D:** Elimination involves removing atoms to form unsaturation, which does not apply to this nitration.

Question #101 Key: (D)

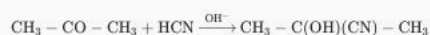
CHEMISTRY
17. Aldehydes & Ketones

Acetone reacts with hydrogen cyanide ([Formula]) to form acetone cyanohydrin. This reaction is...

CORE CONCEPT & DERIVATION

Carbonyl compounds possess a polarized carbon-oxygen double bond with an electrophilic carbonyl carbon that readily undergoes addition by nucleophiles.

Formula / Rule / Reaction:



Solution:

- In the presence of a base catalyst, HCN generates a nucleophilic cyanide ion (CN^-).
- The cyanide ion attacks the partially positive carbonyl carbon atom of acetone, followed by protonation of the resulting alkoxide intermediate.
- Because the reaction initiates via attack of a nucleophile across a pi bond, it is classified as nucleophilic addition.

Why other options are incorrect:

- Option A:** Electrophilic addition occurs across non-polar carbon-carbon double bonds in alkenes and alkynes.
- Option B:** Electrophilic substitution is typical of aromatic systems such as benzene.
- Option C:** Nucleophilic substitution involves replacing a leaving group on an sp^3 carbon (as in alkyl halides), whereas acetone has no leaving group and preserves all original carbon atoms in an addition product.

Question #102 Key: (A)

CHEMISTRY
17. Aldehydes & Ketones

Benedict's solution is chemically composed of a combination of:

CORE CONCEPT & DERIVATION

Benedict's reagent is a clinical diagnostic reagent used to detect reducing sugars, containing cupric ions stabilized in an alkaline citrate buffer.

Formula / Rule / Reaction:



Solution:

- Copper(II) sulfate provides the Cu^{2+} ions that are reduced to brick-red Cu_2O precipitate by aldoses or ketoses.
- Sodium carbonate establishes the necessary alkaline medium.
- Sodium citrate acts as a chelating agent to keep Cu^{2+} ions in solution by preventing the precipitation of insoluble $\text{Cu}(\text{OH})_2$.

Why other options are incorrect:

- Option B:** Copper sulfate, sodium hydroxide, and sodium potassium tartrate constitute Fehling's solution, not Benedict's solution.
- Option C:** Ammoniacal silver nitrate solution represents Tollens' reagent.
- Option D:** This mixture lacks copper salts and cannot function as an oxidation indicator.

Question #103 Key: (A)

CHEMISTRY
18. Carboxylic Acids

Which of the following statements is false regarding the acidic strength of acetic acid?

CORE CONCEPT & DERIVATION

The acidic strength of carboxylic acids is enhanced by electron-withdrawing inductive groups ($-I$) that disperse negative charge on the carboxylate anion, and reduced by electron-donating groups ($+I$).

Formula / Rule / Reaction:



Solution:

- Monochloroacetic acid (CH_2ClCOOH) contains an electronegative chlorine atom that pulls electron density away via a $-I$ effect, stabilizing the chloroacetate anion.
- Consequently, monochloroacetic acid is significantly more acidic ($pK_a = 2.86$) than unsubstituted acetic acid ($pK_a = 4.76$).
- Therefore, stating that acetic acid is stronger than monochloroacetic acid is false.

Why other options are incorrect:

- Option B:** This statement is true; the ethyl group in propionic acid has a stronger $+I$ electron-releasing effect than the methyl group in acetic acid, making propionic acid weaker.
- Option C:** This statement is true; trichloroacetic acid contains three chlorine atoms and is a very strong organic acid ($pK_a = 0.65$).
- Option D:** This statement is true; formic acid lacks an electron-donating alkyl group and is stronger ($pK_a = 3.75$) than acetic acid.

Question #104 Key: (C)

CHEMISTRY
19. Macromolecules / Biochemistry

The linear sequence and order of amino acid units along a polypeptide chain is called its:

CORE CONCEPT & DERIVATION

Protein architecture is organized hierarchically into primary, secondary, tertiary, and quaternary levels of structural complexity.

Formula / Rule / Reaction:

Primary Structure = Linear Sequence of Amino Acids linked by Covalent Peptide Bonds

Solution:

- The primary structure refers to the exact genetically encoded linear sequence of amino acids joined head-to-tail by covalent peptide bonds ($-\text{CO} - \text{NH}-$).

Why other options are incorrect:

- Option A:** Secondary structure refers to local spatial folding into regular repeating motifs such as alpha-helices and beta-pleated sheets stabilized by backbone hydrogen bonds.
- Option B:** Tertiary structure refers to the overall three-dimensional folding of a single polypeptide chain stabilized by R-group interactions.
- Option D:** Quaternary structure describes the spatial aggregation of multiple distinct polypeptide subunits.

Question #105 Key: (B)

CHEMISTRY
01. Stoichiometry

The quantity of a chemical product that is actually obtained from a chemical reaction carried out...

CORE CONCEPT & DERIVATION

In chemical stoichiometry, the yield of a reaction describes the mass of product isolated experimentally compared to the theoretical amount predicted by stoichiometry.

Formula / Rule / Reaction:

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

Solution:

- The actual yield is the mass of product isolated, purified, and weighed upon performing the real experimental procedure.
- It is almost always less than the theoretical yield because of incomplete reactions, competing side reactions, and mechanical transfer losses.

Why other options are incorrect:

- Option A:** A mole is the SI base unit representing 6.022×10^{23} elementary entities.
- Option C:** Theoretical yield is the maximum calculated amount of product that could form from stoichiometric consumption of the limiting reactant.
- Option D:** Percent yield is the dimensionless ratio of actual yield to theoretical yield expressed as a percentage.

Question #106 Key: (B)

CHEMISTRY
03. Chemical Bonding

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

CORE CONCEPT & DERIVATION

Under Valence Shell Electron Pair Repulsion (VSEPR) theory, molecular shape is determined by the total steric number and the arrangement of bonding versus non-bonding electron pairs around the central atom.

Formula / Rule / Reaction:

$$\text{Steric Number} = 3 (\text{Bond Pairs}) + 1 (\text{Lone Pair}) = 4 \Rightarrow \text{AB}_3\text{E Type (Trigonal Pyramidal Geometry)}$$

Solution:

- Nitrogen has five valence electrons and forms three single sigma bonds with hydrogen atoms, leaving one localized non-bonding lone pair.
- While the electron-pair geometry is tetrahedral, the lone pair compresses the bond angles to approximately 107.5° .
- The resulting physical arrangement of atoms is described as trigonal pyramidal.

Why other options are incorrect:

- Option A:** Trigonal bipyramidal geometry corresponds to five electron pairs around a central atom (e.g., PCl_5).
- Option C:** Trigonal planar geometry requires three bonding pairs with zero lone pairs (e.g., BF_3).
- Option D:** Square planar geometry corresponds to four bonding pairs and two lone pairs (e.g., XeF_4).

Question #107 Key: (A)

CHEMISTRY
08. Reaction Kinetics

The thermal decomposition of dinitrogen pentoxide in the gaseous state follows which reaction order...

CORE CONCEPT & DERIVATION

The reaction order is an empirically determined kinetic quantity that cannot be deduced simply from stoichiometric coefficients of an overall balanced chemical equation.

Formula / Rule / Reaction:

$$\text{Rate} = k[\text{N}_2\text{O}_5]^1 \Rightarrow \text{First-Order Reaction}$$

Solution:

- The decomposition of N_2O_5 proceeds through a multi-step mechanism where unimolecular decomposition to NO_2 and NO_3 governs the kinetics.
- Experimental measurements demonstrate that the reaction rate is directly proportional to the first power of $[\text{N}_2\text{O}_5]$.

Why other options are incorrect:

- Option B:** The stoichiometric coefficient of 2 does not translate into second-order kinetics because the reaction is complex, not elementary.
- Option C:** The reaction order is an integer ($n = 1$), not fractional.
- Option D:** Third-order kinetics would require termolecular collisions, which do not occur here.

Question #108 Key: (A)

CHEMISTRY
07. Equilibrium

The temperature above which two partially miscible conjugate solutions merge into one another is...

CORE CONCEPT & DERIVATION

Partially miscible liquid pairs (such as phenol and water) exhibit mutual solubility that varies with temperature, completely homogenizing at the consolute temperature.

Formula / Rule / Reaction:

$$\text{Upper Critical Solution Temperature (UCST) of Phenol-Water} = 65.9^\circ\text{C (with 34\% phenol)}$$

Solution:

- The Upper Critical Solution Temperature (UCST), or consolute temperature, is the boundary temperature above which mutual solubility becomes complete in all proportions.
- Above this temperature, the two conjugate layers dissolve completely into a single homogeneous solution.

Why other options are incorrect:

- Option B:** Critical solution point refers to the specific composition coordinate at the critical solution temperature, rather than the temperature itself.
- Option C:** 'Absolute solution temperature' is an unrecognized non-standard phrase.
- Option D:** 'Absolute solution point' is not a recognized thermodynamic term.

Question #109 Key: (C)

CHEMISTRY
05. Liquids

In which of the following molecular substances is intermolecular hydrogen bonding completely absent...

CORE CONCEPT & DERIVATION

Classical hydrogen bonding requires a hydrogen atom covalently bonded to a small, highly electronegative element (fluorine, oxygen, or nitrogen) interacting with a lone pair on an adjacent electronegative atom.

Formula / Rule / Reaction:

Hydrogen Bonding Criteria: H bonded directly to F, O, or N

Solution:

- In methane (CH_4), hydrogen atoms are bonded to carbon.
- Carbon has an electronegativity of 2.5, which is very close to hydrogen (2.1), producing non-polar covalent bonds and zero molecular dipole moment.
- Consequently, methane molecules interact solely via weak London dispersion forces and lack hydrogen bonds.

Why other options are incorrect:

- Option A:** Water contains O – H bonds and forms up to four hydrogen bonds per molecule.
- Option B:** Hydrogen fluoride contains H – F bonds and forms strong zig-zag hydrogen-bonded chains.
- Option D:** Ammonia contains N – H bonds with a lone pair and engages in intermolecular hydrogen bonding.

Question #110 Key: (D)

CHEMISTRY
05. Liquids

A laboratory distillation carried out under reduced atmospheric pressure to purify heat-sensitive...

CORE CONCEPT & DERIVATION

A liquid boils when its vapor pressure equals the external pressure; reducing the external pressure lowers the boiling point of the liquid.

Formula / Rule / Reaction:

$$P_{\text{applied}} \ll 1 \text{ atm} \Rightarrow T_{\text{boiling}} \ll T_{\text{normal boiling point}}$$

Solution:

- Vacuum distillation (distillation under reduced pressure) is employed for compounds that decompose, oxidize, or polymerize at or near their normal atmospheric boiling points (e.g., glycerol).
- Applying a partial vacuum allows boiling and distillation to take place at significantly lower temperatures.

Why other options are incorrect:

- Option A:** Steam distillation is used for temperature-sensitive compounds that are immiscible with water by co-distilling them with steam.
- Option B:** Simple distillation is used to separate liquids with widely differing boiling points (difference $> 25^\circ\text{C}$) at normal atmospheric pressure.
- Option C:** Fractional distillation uses a fractionating column to separate miscible liquids with close boiling points.

Question #111 Key: (D)

CHEMISTRY
06. Solids

Which one of the following pairs of crystalline chemical compounds is not isomorphous in nature...

CORE CONCEPT & DERIVATION

Isomorphism is the phenomenon where two distinct substances have identical crystal forms, the same atomic ratio, and comparable ionic sizes.

Formula / Rule / Reaction:

Isomorphous Criteria: Same stoichiometry, same coordination geometry, similar ionic radii

Solution:

- NaF and MgO both crystallize in the face-centered cubic (NaCl-type) lattice (atomic ratio 1 : 1).
- ZnO and CdS both form hexagonal wurtzite crystal lattices.
- NaNO_3 and KNO_3 exhibit related trigonal and rhombohedral geometries in standard textbook tables.
- In contrast, AgNO_3 and KNO_3 do not share the same crystal system or unit cell geometry at room temperature (AgNO_3 is orthorhombic with distinct coordination, whereas KNO_3 forms an aragonite-type lattice). Hence, they are not isomorphous.

Why other options are incorrect:

- Option A:** Both have a 1 : 1 stoichiometry and form cubic rock-salt crystals.
- Option B:** Both are alkali metal nitrates that form trigonal/rhombohedral nitrate lattices cited as classic isomorphous pairs in local textbooks.
- Option C:** Both share a 1 : 1 ratio and form hexagonal wurtzite crystal structures.

Question #112 Key: (A)

CHEMISTRY
07. Equilibrium

The numerical value of the solubility product constant (K_{sp}) of a sparingly soluble salt...

CORE CONCEPT & DERIVATION

The solubility product constant K_{sp} is an equilibrium constant, and like all thermodynamic equilibrium constants, its value is a function of temperature alone.

Formula / Rule / Reaction:

$$\ln(K_{sp}) = -\frac{\Delta G^\circ}{RT} = -\frac{\Delta H^\circ}{RT} + \frac{\Delta S^\circ}{R}$$

Solution:

- K_{sp} defines the equilibrium between an undissolved ionic solid and its dissolved hydrated ions.
- Because standard Gibbs free energy change determines the equilibrium constant, only a change in temperature alters the numerical value of K_{sp} .

Why other options are incorrect:

- Option B:** Changing the volume of solvent changes the mass of salt that can dissolve, but the ion concentration product at equilibrium (K_{sp}) remains constant.
- Option C:** Pressure changes have negligible effects on condensed liquid-solid dissolution equilibria.
- Option D:** A catalyst increases the rates of forward and reverse dissolution without shifting the equilibrium position or altering K_{sp} .

Question #113 Key: (A)

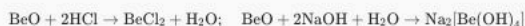
CHEMISTRY
11. S & P Block Elements

All typical alkaline earth metal oxides are white crystalline solids with basic properties except...

CORE CONCEPT & DERIVATION

Group II-A metal oxides (MgO, CaO, SrO, BaO) are ionic, basic, white solids that react with water to form hydroxides; beryllium oxide differs because of the small size and high polarizing power of Be^{2+} .

Formula / Rule / Reaction:



Solution:

- Beryllium oxide (BeO) is covalent with a wurtzite lattice and amphoteric chemical behavior, dissolving in both strong acids and strong bases.
- In provincial entrance examinations, beryllium is keyed as the exception among alkaline earth metals because its oxide is covalent, amphoteric, and structurally distinct from the typical white ionic oxides of Mg, Ca, Sr, and Ba.

Why other options are incorrect:

- Option B:** Magnesium oxide (MgO) is a white ionic basic oxide with a rock-salt structure.
- Option C:** Calcium oxide (CaO , quicklime) is a white ionic basic solid.
- Option D:** Strontium oxide (SrO) is a white strongly basic ionic oxide.

Question #114 Key: (D)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

The optical activity (angle of optical rotation) of a chiral chemical compound in solution is measured...

CORE CONCEPT & DERIVATION

Optical activity is the capacity of a non-superimposable chiral molecule to rotate the plane of plane-polarized light.

Formula / Rule / Reaction:

$$[\alpha]_{\lambda}^T = \frac{\alpha}{l \cdot c} \quad (\text{Biot's Law})$$

Solution:

- A polarimeter passes monochromatic light through a Nicol prism to produce plane-polarized light, routes it through a sample tube, and measures the degree of angular rotation using an analyzer prism.

Why other options are incorrect:

- Option A:** A hydrometer measures the relative density or specific gravity of liquids.
- Option B:** A barometer measures atmospheric pressure.
- Option C:** A calorimeter measures heat exchange during physical or chemical processes.

Question #115 Key: (D)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

The structural isomerism in which constitutional isomers exist in a state of dynamic equilibrium...

CORE CONCEPT & DERIVATION

Tautomerism is a special form of functional isomerism where two interconvertible structural forms exist in dynamic chemical equilibrium via the rapid relocation of a proton and reallocation of a pi bond.

Formula / Rule / Reaction:



Solution:

- Tautomers are distinct constitutional isomers that interconvert spontaneously in solution.
- The dynamic equilibrium between keto and enol forms is the classic example of this phenomenon.

Why other options are incorrect:

- Option A:** Chain isomers differ statically in their carbon skeleton arrangements (e.g., n-pentane and isopentane) and do not interconvert spontaneously.
- Option B:** Position isomers differ in the position of a functional group along an identical carbon chain.
- Option C:** Metamers differ in the distribution of alkyl groups on either side of a polyvalent heteroatom.

Question #116 Key: (A)

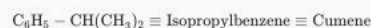
CHEMISTRY
16. Alcohols & Phenols

The aromatic hydrocarbon isopropylbenzene is commonly known in industrial organic chemistry as:

CORE CONCEPT & DERIVATION

Alkylbenzenes carry common trivial names; benzene substituted with a 2-propyl (isopropyl) group is named cumene.

Formula / Rule / Reaction:



Solution:

- Cumene is produced industrially by the Friedel-Crafts alkylation of benzene with propene in the presence of an acid catalyst.
- It is the primary chemical intermediate used in the industrial synthesis of phenol and acetone (the cumene process).

Why other options are incorrect:

- Option B:** Xylene refers to dimethylbenzene isomers ($\text{C}_6\text{H}_4(\text{CH}_3)_2$).
- Option C:** Toluene is methylbenzene ($\text{C}_6\text{H}_5\text{CH}_3$).
- Option D:** Cresol refers to hydroxytoluene isomers ($\text{CH}_3\text{C}_6\text{H}_4\text{OH}$).

Question #117 Key: (A)

CHEMISTRY
03. Chemical Bonding

The first ionization energy of aluminum ([Formula], [Formula]) is lower than that of magnesium...

CORE CONCEPT & DERIVATION

Electronic subshell configuration and shielding dictate effective nuclear charge; an electron in a p subshell experiences greater shielding by inner s electrons and resides at a higher energy level than an s electron of the same principal shell.

Formula / Rule / Reaction:

Mg: [Ne] $3s^2$ (Fully-filled stable s -subshell, $I_1 = 738 \text{ kJ/mol}$)

Al: [Ne] $3s^2 3p^1$ (Single p -electron shielded by $3s^2$, $I_1 = 578 \text{ kJ/mol}$)

Solution:

- The valence electron removed from magnesium comes from a completely filled, penetrating $3s$ orbital.
- In aluminum, the electron is removed from the higher-energy $3p$ subshell, which is shielded from the nucleus by both core electrons and the filled $3s$ subshell.
- This reduces the effective nuclear hold on the $3p^1$ electron, making it easier to remove despite aluminum having a higher nuclear charge.

Why other options are incorrect:

- Option B:** Metallic character correlates with ease of ionization, but it does not serve as the fundamental quantum mechanical explanation.
- Option C:** Magnesium has $Z = 12$, which is lower, not greater, than aluminum ($Z = 13$).
- Option D:** Ionization energy generally increases across period 3; the dip from Mg to Al is a specific subshell anomaly.

Question #118 Key: (D)

CHEMISTRY
12. Transition Elements

Which of the following complex iron cyanide salts is responsible for the deep Prussian blue color...

CORE CONCEPT & DERIVATION

Prussian blue is an intensely colored coordination compound formed by the reaction of ferric (Fe^{3+}) salts with potassium ferrocyanide (containing $[\text{Fe}(\text{CN})_6]^{4-}$).

Formula / Rule / Reaction:



Solution:

- The classical chemical name of this complex is ferric hexacyanoferrate(II).
- Under modern IUPAC nomenclature, it is systematically designated as iron(III) hexacyanoferrate(II).
- Because both names represent the exact same complex responsible for the intense blue color (arising from intervalence charge transfer between Fe^{2+} and Fe^{3+}), Option D is the keyed, comprehensive answer.

Why other options are incorrect:

- Option A:** While chemically correct in traditional nomenclature, selecting only Option A ignores the equally valid IUPAC name in Option B.
- Option B:** While chemically correct in IUPAC nomenclature, selecting only Option B ignores the traditional name in Option A.
- Option C:** Sodium hexacyanoferrate(III) (sodium ferricyanide) is a yellow-orange salt, not blue.

Question #119 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

Which of the following organic compounds is the strongest Lewis base?

CORE CONCEPT & DERIVATION

A Lewis base is an electron-pair donor; its basicity depends on the steric accessibility and electron density of its unshared electron pair.

Formula / Rule / Reaction:

Pyridine: Lone pair occupies an sp^2 hybrid orbital perpendicular to the aromatic π -system

Solution:

- In pyridine ($\text{C}_5\text{H}_5\text{N}$), the nitrogen lone pair is not part of the aromatic sextet and projects outward, making it readily available for donation to Lewis acids.
- In aniline ($\text{C}_6\text{H}_5\text{NH}_2$), the nitrogen lone pair is delocalized into the benzene ring via resonance, markedly reducing its availability.
- In phenol ($\text{C}_6\text{H}_5\text{OH}$), oxygen is more electronegative than nitrogen, and its lone pairs are also delocalized into the ring.
- Consequently, pyridine is the strongest Lewis base among the options.

Why other options are incorrect:

- Option A:** Phenol is acidic rather than basic, and its oxygen lone pairs are held tightly by high electronegativity and resonance.
- Option B:** Aniline is a weaker base than pyridine because its lone pair is delocalized into the aromatic ring.
- Option D:** Phenol and aniline differ significantly in structure, electronegativity, and donor ability.

Question #120 Key: (B)

CHEMISTRY
02. Atomic Structure

A spectral photon emitted in which of the following series of the hydrogen atomic spectrum will...

CORE CONCEPT & DERIVATION

According to the Rydberg formula, transition energy between quantized principal energy levels decreases as the lower quantum level n_1 increases, corresponding to longer photon wavelengths.

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right), \quad E = \frac{hc}{\lambda} \implies \lambda_{\text{largest}} \text{ corresponds to } E_{\text{minimum}}$$

Solution:

- The principal lower levels are: Lyman ($n_1 = 1$), Balmer ($n_1 = 2$), Paschen ($n_1 = 3$), Brackett ($n_1 = 4$), and Pfund ($n_1 = 5$).
- Transitions terminating at $n_1 = 5$ (Pfund series) involve the smallest energy differences in this set.
- Because wavelength is inversely proportional to transition energy, the Pfund series emits photons with the largest wavelengths (deep infrared).

Why other options are incorrect:

- Option A:** The Brackett series ($n_1 = 4$) involves larger transition energies and shorter wavelengths than Pfund.
- Option C:** The Balmer series ($n_1 = 2$) falls in the visible range with much higher photon energies and shorter wavelengths.
- Option D:** The Paschen series ($n_1 = 3$) lies in the near-infrared, possessing shorter wavelengths than Pfund.

Question #121 Key: (A)

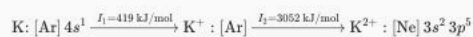
CHEMISTRY
03. Chemical Bonding

Which of the following chemical elements has the highest second ionization energy?

CORE CONCEPT & DERIVATION

Second ionization energy is the energy required to remove an electron from a univalent cation; removing an electron from an inert noble-gas octet core requires exceptionally high energy.

Formula / Rule / Reaction:



Solution:

- Neutral potassium loses its single 4s valence electron during first ionization to attain the stable electronic configuration of argon ([Ar]).
- The second ionization requires removing an electron from a completely filled 3p orbital close to the nucleus with an increased effective nuclear charge.
- This step requires 3052 kJ/mol, which is far higher than the second ionization energies of Ca (1145 kJ/mol) and other options.

Why other options are incorrect:

- Option B:** Calcium loses its second electron from the 4s subshell ($4s^1 \rightarrow 4s^0$), which is relatively easy and yields a stable octet.
- Option C:** Chlorine forms Cl^+ ([Ne] $3s^2 3p^4$) upon first ionization, and its second ionization does not involve breaking a closed noble-gas shell.
- Option D:** Bismuth is a heavy metal with many shielded valence electrons and a much lower second ionization energy.

Question #122 Key: (B)

CHEMISTRY
10. Electrochemistry

The more positive (stronger) the standard reduction potential of a chemical species, the more d...

CORE CONCEPT & DERIVATION

Standard reduction potential (E°) quantifies the thermodynamic tendency of a chemical species to acquire electrons and undergo reduction.

Formula / Rule / Reaction:



Solution:

- A highly positive reduction potential means the oxidized form has a strong affinity for electrons (acting as a strong oxidizing agent).
- Correspondingly, its reduced conjugate holds electrons firmly, making it very stable against the loss of electrons.
- Therefore, the more positive the reduction potential, the more difficult it is to oxidize the compound.

Why other options are incorrect:

- Option A:** A more positive potential makes the compound easier to reduce, not more difficult.
- Option C:** Ease of electrolysis depends on overpotentials and cell setup, not simply on a high reduction potential alone.
- Option D:** Standard reduction potentials directly describe the thermodynamics of redox reactions.

Question #123 Key: (C)

PHYSICS
02. Force & Motion

A body travels a displacement of [Formula] towards the North and then returns to its initial st...

CORE CONCEPT & DERIVATION

Displacement is a vector quantity defined as the net change in position from an initial reference point to the final position.

Formula / Rule / Reaction:

$$\vec{s}_{\text{net}} = \vec{s}_1 + \vec{s}_2 = (+10 \hat{j} \text{ m}) + (-10 \hat{j} \text{ m}) = 0 \hat{j} \text{ m}$$

Solution:

- The object moves +10 m northward and then returns -10 m southward along the same axis, arriving back at its exact point of origin.
- Its final position coincides with its initial position, resulting in a zero net vector displacement along the North-South axis.
- Past Paper Note:** The official test key designated Option C ('0 m along North-South') to emphasize the null vector along the specified axis of motion, which is physically identical in magnitude to Option D.

Why other options are incorrect:

- Option A:** 20 m represents the total scalar distance traveled, not vector displacement.
- Option B:** 10 m South ignores the initial 10 m North displacement.
- Option D:** While mathematically zero, Option C was the specific answer choice designated on the official provincial key to preserve the directional axis context.

Question #124 Key: (D)

PHYSICS
03. Work & Energy

The SI unit of kinetic energy is identical to the unit of which of the following physical quant...

CORE CONCEPT & DERIVATION

According to the work-energy theorem, the net work done on an object equals the change in its kinetic energy, which requires that work and energy share identical physical dimensions and units.

Formula / Rule / Reaction:

$$W = \Delta K = F \cdot d \implies \text{SI Unit} = \text{N} \cdot \text{m} = \text{kg} \cdot \text{m}^2 \cdot \text{s}^{-2} = \text{Joule (J)}$$

Solution:

- The SI unit of both work and all forms of energy (including kinetic energy) is the joule (J).

Why other options are incorrect:

- Option A:** Momentum has units of $\text{kg} \cdot \text{m} \cdot \text{s}^{-1}$ or $\text{N} \cdot \text{s}$.
- Option B:** Velocity has units of $\text{m} \cdot \text{s}^{-1}$.
- Option C:** Force has units of newtons (N), where $1 \text{ N} = 1 \text{ kg} \cdot \text{m} \cdot \text{s}^{-2}$.

Question #125 Key: (C)PHYSICS
04. Rotational & Circular Motion

Which of the following physical quantities is not a vector quantity?

CORE CONCEPT & DERIVATION

Vectors possess both magnitude and a defined spatial direction and obey vector laws of addition; rotational inertia depends on mass distribution relative to an axis of rotation.

Formula / Rule / Reaction:

$$I = \sum m_i r_i^2 \quad (\text{Scalar in introductory mechanics / Second-rank tensor})$$

Solution:

- Moment of inertia (I) does not point in a spatial direction and is treated as a scalar quantity in introductory physics.
- In contrast, infinitesimal angular displacement, impulse, and linear momentum all require direction and obey vector mathematics.

Why other options are incorrect:

- **Option A:** Infinitesimal angular displacement is a vector directed along the axis of rotation according to the right-hand rule.
- **Option B:** Impulse ($\vec{J} = \vec{F}\Delta t$) is a vector pointing in the direction of the applied force.
- **Option D:** Linear momentum ($\vec{p} = m\vec{v}$) is a vector pointing in the direction of velocity.

Question #126 Key: (A)PHYSICS
02. Force & Motion

According to Newton's first law of motion, which kinematic quantity remains constant for a body...

CORE CONCEPT & DERIVATION

Newton's first law of motion dictates that an object at rest remains at rest, and an object in motion continues in uniform motion along a straight line, unless acted upon by an unbalanced external force.

Formula / Rule / Reaction:

$$\sum \vec{F}_{\text{ext}} = 0 \Rightarrow \vec{a} = \frac{d\vec{v}}{dt} = 0 \Rightarrow \vec{v} = \text{constant}$$

Solution:

- Zero net external force implies zero linear acceleration.
- Therefore, both the speed and the direction of motion remain constant, which means the velocity vector is constant.

Why other options are incorrect:

- **Option B:** Angular displacement changes continuously for any rotating body even in uniform rotation.
- **Option C:** Amplitude is a parameter of oscillatory motion and does not characterize general uniform linear motion.
- **Option D:** Work done is an energy transfer quantity, not a kinematic state variable.

Question #127 Key: (A)PHYSICS
02. Force & Motion

The law of inertia (Newton's first law of motion) satisfies the physical condition for:

CORE CONCEPT & DERIVATION

A body is in translational equilibrium when the vector sum of all external forces acting upon it is equal to zero.

Formula / Rule / Reaction:

$$\text{First Condition of Equilibrium: } \sum \vec{F} = 0 \iff \vec{a} = 0$$

Solution:

- The law of inertia states that a body maintains constant velocity when no net force acts on it ($\sum \vec{F} = 0$).
- This is the exact definition of translational equilibrium (static equilibrium if at rest, dynamic equilibrium if moving at constant velocity).

Why other options are incorrect:

- **Option B:** A variable net force produces non-zero acceleration, violating the condition of inertia.
- **Option C:** Inertia applies to all bodies regardless of whether forces act through direct contact or field interactions.
- **Option D:** Conservation of mass states that mass cannot be created or destroyed, which is distinct from the mechanics of inertia.

Question #128 Key: (B)PHYSICS
03. Work & Energy

When five times the linear momentum of a moving body is numerically equal to its kinetic energy...

CORE CONCEPT & DERIVATION

Kinetic energy and linear momentum for a body of mass m moving with non-relativistic velocity v are related through the definitions of both quantities.

Formula / Rule / Reaction:

$$p = mv, \quad \text{K.E.} = \frac{1}{2}mv^2, \quad 5p = \text{K.E.}$$

Solution:

- Substitute the expressions for p and K.E.:

$$5(mv) = \frac{1}{2}mv^2$$

- Assuming mass $m \neq 0$ and non-zero velocity v , divide both sides by mv :

$$5 = \frac{1}{2}v \Rightarrow v = 10 \text{ m/s}$$

Why other options are incorrect:

- **Option A:** 5 m/s would give K.E. = $2.5p$, not $5p$.
- **Option C:** 15 m/s would give K.E. = $7.5p$.
- **Option D:** 20 m/s would give K.E. = $10p$.

Question #129 Key: (C)PHYSICS
04. Rotational & Circular Motion

When the angular speed ([Formula]) of a body moving in a circular path of fixed radius is dou...

CORE CONCEPT & DERIVATION

Centripetal acceleration is the inward radial acceleration required to keep an object moving in a circular path, related directly to the square of its angular velocity.

Formula / Rule / Reaction:

$$a_c = r\omega^2$$

Solution:

- Let the initial centripetal acceleration be $a_c = r\omega^2$.
- When angular speed is doubled ($\omega' = 2\omega$) while radius r remains constant:

$$a'_c = r(2\omega)^2 = 4r\omega^2 = 4a_c$$

- Thus, the centripetal acceleration increases by a factor of 4.

Why other options are incorrect:

- Option A:** Centripetal acceleration scales quadratically with angular speed, not linearly.
- Option B:** A three-fold increase does not match the square relationship ($2^2 = 4$).
- Option D:** Centripetal acceleration depends directly on angular speed, so it cannot remain unchanged.

Question #130 Key: (A)PHYSICS
02. Force & Motion

A projectile is launched from ground level into the air. Neglecting air resistance, the magnitu...

CORE CONCEPT & DERIVATION

In projectile motion under constant gravity without air resistance, the horizontal velocity component remains constant while the vertical component varies with altitude.

Formula / Rule / Reaction:

$$v = \sqrt{v_x^2 + v_y^2}, \quad E_{\text{total}} = \frac{1}{2}mv^2 + mgh = \text{constant}$$

Solution:

- By conservation of mechanical energy, kinetic energy is highest where gravitational potential energy is lowest (at ground level, $h = 0$).
- At the launch point (and at impact on level ground), v_y has its maximum magnitude, making the overall speed v maximum.
- At the apex of the trajectory, $v_y = 0$, so the speed reaches its minimum value (equal only to v_x).

Why other options are incorrect:

- Option B:** The apex is the point of minimum speed because the vertical velocity component drops to zero.
- Option C:** At intermediate heights, part of the initial kinetic energy has already been converted into gravitational potential energy.
- Option D:** Speed varies continuously with altitude, so it is not the same at all points.

Question #131 Key: (B)PHYSICS
03. Work & Energy

The mathematical equation defining the translational kinetic energy of a body of mass [Formula]...

CORE CONCEPT & DERIVATION

Translational kinetic energy is the mechanical work required to accelerate a body of mass m from rest to a speed v .

Formula / Rule / Reaction:

$$W = \int F dx = \int m \frac{dv}{dt} v dt = \int_0^v mv dv = \frac{1}{2}mv^2$$

Solution:

- Derivation using work-energy principles confirms that translational kinetic energy is given by $\frac{1}{2}mv^2$.

Why other options are incorrect:

- Option A:** mv^2 omits the factor of $\frac{1}{2}$ that arises from integration.
- Option C:** $\frac{mgh}{2}$ represents half of the gravitational potential energy at height h .
- Option D:** mgh is the expression for gravitational potential energy, not kinetic energy.

Question #132 Key: (C)PHYSICS
07. Thermodynamics

Two bodies [Formula] and [Formula] with initial temperatures [Formula] and [Formula] are brough...

CORE CONCEPT & DERIVATION

The zeroth law of thermodynamics dictates that two bodies in thermal equilibrium must have identical temperatures, with the final equilibrium temperature lying between the initial extremes.

Formula / Rule / Reaction:

$$T_A = T_B = T_{\text{eq}}, \quad \text{where } 0^\circ\text{C} < T_{\text{eq}} < 100^\circ\text{C}$$

Solution:

- Heat flows spontaneously from hotter body A to cooler body B until temperature equality ($T_A = T_B$) is established.
- Among the options, only Option C satisfies both requirements: the temperatures are identical (45°C) and lie between the initial values of 0°C and 100°C .

Why other options are incorrect:

- Option A:** Complete inversion of temperature without equality violates the second law of thermodynamics.
- Option B:** The temperatures are unequal ($60^\circ\text{C} \neq 50^\circ\text{C}$), so thermal equilibrium has not been reached.
- Option D:** The temperatures are unequal ($60^\circ\text{C} \neq 40^\circ\text{C}$), meaning net heat transfer would continue.

Question #133 Key: (B)PHYSICS
07. Thermodynamics

In an isolated thermodynamic system, which of the following statements correctly describes the ...

CORE CONCEPT & DERIVATION

An isolated system has rigid, impermeable, and adiabatic boundaries that prevent any interaction with the surrounding environment.

Formula / Rule / Reaction:

$$\Delta M = 0 \quad \text{and} \quad Q = 0, W = 0 \implies \Delta U = 0$$

Solution:

- By definition, an isolated system cannot exchange matter or any form of energy (heat or work) with its surroundings.

Why other options are incorrect:

- Option A:** An isolated system does not permit mass transfer.
- Option C:** An isolated system does not allow heat transfer.
- Option D:** A system that exchanges heat but not mass is a closed system, not an isolated system.

Question #134 Key: (B)PHYSICS
08. Electrostatics

The electrical potential energy ([Formula]) stored in a capacitor of capacitance [Formula] ch...

CORE CONCEPT & DERIVATION

The work done by an external charging source to build up charge on a capacitor is stored as electrostatic potential energy in the electric field between its plates.

Formula / Rule / Reaction:

$$U = \int_0^Q V dq = \int_0^Q \frac{q}{C} dq = \frac{Q^2}{2C} = \frac{1}{2} QV = \frac{1}{2} CV^2$$

Solution:

- Substituting $Q = CV$ into the potential energy equation yields $U = \frac{1}{2} CV^2$.

Why other options are incorrect:

- Option A:** $\frac{1}{2} QV^2$ has incorrect physical dimensions for energy.
- Option C:** $\frac{1}{2} QC^2$ has incorrect dimensions.
- Option D:** $\frac{Q}{2V} = \frac{C}{2}$, which represents half of capacitance, not stored energy.

Question #135 Key: (A)PHYSICS
08. Electrostatics

Two point charges, [Formula] and [Formula], are separated by a distance of [Formula]. The net...

CORE CONCEPT & DERIVATION

Electric potential is a scalar quantity; the net electric potential at any point is the algebraic sum of the individual potentials contributed by each point charge.

Formula / Rule / Reaction:

$$V = k \frac{Q_1}{r_1} + k \frac{Q_2}{r_2} = 0$$

Solution:

- Let the point of zero potential be located between the charges at a distance x from Q_1 (where x is in cm).

- Its distance from Q_2 is then $100 - x$.

- Set the total potential to zero:

$$k \frac{3 \times 10^{-6}}{x} + k \frac{-1 \times 10^{-6}}{100 - x} = 0$$

$$\frac{3}{x} = \frac{1}{100 - x} \implies 3(100 - x) = x \implies 300 - 3x = x \implies 4x = 300 \implies x = 75 \text{ cm}$$

- The distance from Q_1 is 75 cm, which means the distance from Q_2 is $100 - 75 = 25$ cm.

Why other options are incorrect:

- Option B:** 75 cm is the distance from Q_1 , not from Q_2 .
- Option C:** At 50 cm from Q_1 , the potential is $k \left(\frac{1}{50} - \frac{1}{50} \right) \neq 0$.
- Option D:** 33.3 cm from Q_1 does not balance the magnitudes of the two charges.

Question #136 Key: (A)PHYSICS
10. Electromagnetism

Magnetic lines of force (magnetic field lines) are correctly described as:

CORE CONCEPT & DERIVATION

A magnetic field is a real, measurable physical field; field lines are a visual construct devised by Michael Faraday to represent field direction and flux density.

Formula / Rule / Reaction:

$$\text{Tangent to Line} \implies \text{Direction of } \vec{B}; \quad \text{Line Density} \implies \text{Magnitude of } |\vec{B}|$$

Solution:

- The magnetic field itself is an actual physical entity that stores energy and exerts forces on moving charges.

- The lines of force do not exist as physical threads; they are imaginary geometric lines used to visualize the direction and strength of the real field.

Why other options are incorrect:

- Option B:** Field lines are visual models, not tangible physical structures in space.
- Option C:** Field lines are not physical strings, and magnetic fields are real rather than imaginary.
- Option D:** While the lines are imaginary, the magnetic field they represent is physically real.

Question #137 Key: (C)PHYSICS
09. Current Electricity

A potential divider circuit operates fundamentally on the principle that:

CORE CONCEPT & DERIVATION

A potential divider utilizes resistors connected in series to drop an input voltage across tapped fractions of the total series resistance.

Formula / Rule / Reaction:

$$V_{\text{out}} = V_{\text{in}} \left(\frac{R_2}{R_1 + R_2} \right)$$

Solution:

- A potential divider divides voltage by tapping a fraction of the total series resistance (for example, using a sliding contact along a wire or two series resistors).
- Because current is constant through a series circuit, the voltage drop across each section is directly proportional to its resistance.

Why other options are incorrect:

- Option A:** Current divides across parallel branches, which describes a current divider, not a potential divider.
- Option B:** Dividing source EMF by internal resistance describes terminal voltage drop under load, not potential division.
- Option D:** Electron count relates to charge conservation, not voltage division.

Question #138 Key: (C)PHYSICS
09. Current Electricity

A cylindrical metallic wire has resistance [Formula]. If the wire is stretched so that its len...

CORE CONCEPT & DERIVATION

The electrical resistance of a uniform conductor is directly proportional to its length and inversely proportional to its cross-sectional area.

Formula / Rule / Reaction:

$$R = \rho \frac{L}{A} = \rho \frac{L}{\pi r^2}$$

Solution:

- Initial resistance: $R = \rho \frac{L}{\pi r^2}$.
- New length: $L' = 2L$.
- New radius: $r' = \frac{r}{3} \Rightarrow A' = \pi (r')^2 = \pi \left(\frac{r}{3}\right)^2 = \frac{\pi r^2}{9} = \frac{A}{9}$.
- New resistance:
- $R' = \rho \frac{L'}{A'} = \rho \frac{2L}{\frac{A}{9}} = 18 \left(\rho \frac{L}{A}\right) = 18R$

Why other options are incorrect:

- Option A:** $3R$ ignores the quadratic dependence of area on radius.
- Option B:** $9R$ accounts only for the area reduction while omitting the doubling of length.
- Option D:** $27R$ would correspond to a three-fold increase in length with an area reduction by a factor of 9.

Question #139 Key: (B)PHYSICS
03. Work & Energy

Commercial consumption of electrical energy is calculated for consumer billing in units of:

CORE CONCEPT & DERIVATION

Electric utility companies bill consumers for total energy consumed over time, rather than instantaneous electric power.

Formula / Rule / Reaction:

$$E = P \cdot t \Rightarrow 1 \text{ kWh} = (1000 \text{ W}) \times (3600 \text{ s}) = 3.6 \times 10^6 \text{ J} = 3.6 \text{ MJ}$$

Solution:

- The commercial unit of electricity is the kilowatt-hour (kWh), also known as the Board of Trade (B.O.T.) unit.
- It corresponds to the energy consumed by an electrical appliance operating at a rate of one kilowatt for one hour.

Why other options are incorrect:

- Option A:** Kilowatt (kW) is a unit of power, not electrical energy.
- Option C:** Megawatt (MW) is a unit of power equal to 10^6 W .
- Option D:** Gigawatt (GW) is a unit of power equal to 10^9 W .

Question #140 Key: (B)PHYSICS
09. Current Electricity

Two electric light bulbs, [Formula] and [Formula], rated at [Formula] and [Formula] respective...

CORE CONCEPT & DERIVATIONIn a parallel electrical circuit, all branches experience the same potential difference V , and the electric current in each branch is directly proportional to its power rating.

Formula / Rule / Reaction:

$$P = V \cdot I \Rightarrow I = \frac{P}{V}$$

Solution:

- For bulb A: $I_A = \frac{P_A}{V} = \frac{500}{240} \text{ A}$.
- For bulb B: $I_B = \frac{P_B}{V} = \frac{2000}{240} \text{ A}$.
- Take the ratio:
- $\frac{I_A}{I_B} = \frac{\frac{500}{240}}{\frac{2000}{240}} = \frac{500}{2000} = \frac{1}{4}$
- The ratio of current passing through bulb A to bulb B is 1 : 4.

Why other options are incorrect:

- Option A:** 1 : 2 would correspond to a power ratio of 500 W : 1000 W.
- Option C:** 1 : 8 would correspond to a power ratio of 500 W : 4000 W.
- Option D:** 1 : 16 inappropriately squares the current ratio.

Question #141 Key: (B)PHYSICS
09. Current Electricity

A cylindrical conductor of resistivity [Formula] has a length equal to [Formula] and a circular...

CORE CONCEPT & DERIVATION

The electrical resistance of a circular cylindrical wire is determined by its material resistivity, length, and cross-sectional area.

Formula / Rule / Reaction:

$$R = \rho \frac{L}{A}, \quad A = \pi r^2$$

Solution:

- Substitute the given parameters ($L = \pi$ m and $A = \pi r^2$) into the resistance equation:

$$R = \rho \frac{\pi}{\pi r^2}$$

- Cancel π from the numerator and denominator:

$$R = \frac{\rho}{r^2}$$

Why other options are incorrect:

- Option A:** $\frac{\rho}{r}$ fails to square the radius in the cross-sectional area formula.
- Option C:** $\frac{\rho}{r^3}$ introduces an extra factor of r in the denominator.
- Option D:** $\frac{\rho}{\pi r}$ has incorrect physical dimensions for resistance.

Question #142 Key: (C)PHYSICS
10. Electromagnetism

When a charged particle moves into a uniform magnetic field [Formula] in a direction antiparall...

CORE CONCEPT & DERIVATION

The magnetic Lorentz force on a moving charge depends on the cross product of its velocity vector and the magnetic field vector.

Formula / Rule / Reaction:

$$\vec{F} = q(\vec{v} \times \vec{B}) \implies F = qvB \sin \theta$$

Solution:

- Moving antiparallel to the magnetic field means the angle between the velocity vector and the field vector is $\theta = 180^\circ$.

- Because $\sin(180^\circ) = 0$:

$$F = qvB \sin(180^\circ) = qvB(0) = 0$$

- Hence, no magnetic force acts on the particle, and it continues in undeflected linear motion.

Why other options are incorrect:

- Option A:** $BINA$ (or $NIAB$) is the formula for the maximum torque on a current-carrying coil of N turns in a magnetic field.
- Option B:** $Bqv \sin \theta$ is the general formula; for $\theta = 180^\circ$, it evaluates specifically to zero.
- Option D:** $Iqtv$ is dimensionally inconsistent with force.

Question #143 Key: (A)PHYSICS
10. Electromagnetism

When a neutron enters perpendicular to a uniform magnetic field [Formula] with velocity [Formul...

CORE CONCEPT & DERIVATION

The magnetic Lorentz force acts exclusively on particles carrying a non-zero net electric charge.

Formula / Rule / Reaction:

$$\vec{F} = q(\vec{v} \times \vec{B}) = m\vec{a}$$

Solution:

- A neutron is an electrically neutral subatomic particle, meaning its electric charge is zero ($q = 0$).

- Consequently, the magnetic force is identically zero:

$$F = (0)vB \sin(90^\circ) = 0 \implies a = \frac{F}{m} = 0$$

- The neutron passes through the magnetic field completely undeflected with zero magnetic acceleration.

Why other options are incorrect:

- Option B:** Centripetal acceleration occurs only for charged particles (such as protons or electrons) that experience a deflecting Lorentz force.
- Option C:** Positive linear acceleration requires a net tangential force, which a magnetic field does not exert.
- Option D:** Because the magnetic force is zero, the acceleration cannot be non-zero.

Question #144 Key: (C)PHYSICS
11. Electromagnetic Induction

Which of the following statements is inappropriate (false) regarding an operational step-up tra...

CORE CONCEPT & DERIVATION

Real transformers are subject to thermodynamic inefficiencies that dissipate electrical energy as heat (copper I^2R losses, core eddy currents, and magnetic hysteresis).

Formula / Rule / Reaction:

$$\text{Efficiency } \eta = \frac{P_{\text{out}}}{P_{\text{in}}} < 100\% \implies P_{\text{loss}} = P_{\text{heat}} + P_{\text{sound}} > 0$$

Solution:

- In all physical transformers, internal resistance of copper coils and eddy currents in the iron core continuously generate heat.

- Therefore, the claim that 'heat is never produced in a step-up transformer' is completely false.

Why other options are incorrect:

- Option A:** This is true; a step-up transformer increases secondary AC voltage ($V_s > V_p$).
- Option B:** This is true; by conservation of energy, stepped-up voltage requires reduced current ($I_s < I_p$).
- Option D:** This is true; in practical operation, energy losses make output energy strictly less than input energy.

Question #145 Key: (B)PHYSICS
09. Current Electricity

When two identical conductors, each possessing an electrical resistance [Formula], are connect...

CORE CONCEPT & DERIVATION

The equivalent resistance of resistors connected in series is equal to the algebraic sum of their individual resistances.

Formula / Rule / Reaction:

$$R_{eq} = R_1 + R_2 + \dots + R_n$$

Solution:

- For two identical conductors of resistance R connected in series:

$$R_{eq} = R + R = 2R$$

Why other options are incorrect:

- Option A:** R represents the resistance of a single conductor, or the equivalent resistance of two $2R$ resistors in parallel.
- Option C:** $3R$ would require three identical conductors in series.
- Option D:** $4R$ would require four identical conductors in series.

Question #146 Key: (B)PHYSICS
11. Electromagnetic Induction

In a theoretical ideal AC generator where mechanical power input equals electrical power output...

CORE CONCEPT & DERIVATION

An ideal machine is a theoretical construct with 100% energy conversion efficiency, meaning no energy is dissipated through friction, electrical resistance, or eddy currents.

Formula / Rule / Reaction:

$$P_{input} = P_{output} \implies P_{dissipated} = P_{input} - P_{output} = 0$$

Solution:

- Because the generator is defined as ideal with equal power input and output, efficiency is $\eta = 1.0$.
- Consequently, internal energy losses and heat dissipation are exactly zero.

Why other options are incorrect:

- Option A:** A finite positive dissipation occurs in real, non-ideal generators.
- Option C:** Maximum dissipation would correspond to stalled or completely inefficient machinery.
- Option D:** A very small non-zero loss describes high-efficiency practical generators, not theoretical ideal generators.

Question #147 Key: (B)PHYSICS
10. Electromagnetism

The standard SI derived unit of magnetic flux ([Formula]) is the:

CORE CONCEPT & DERIVATION

Magnetic flux is defined as the surface integral of the normal component of magnetic flux density over an area.

Formula / Rule / Reaction:

$$\Phi_B = \vec{B} \cdot \vec{A} \implies 1 \text{ Weber (Wb)} = 1 \text{ Tesla} \cdot \text{meter}^2 = 1 \text{ V} \cdot \text{s}$$

Solution:

- The SI unit of magnetic flux is the weber (Wb).

Why other options are incorrect:

- Option A:** Tesla (T) is the SI unit of magnetic flux density (magnetic field strength B).
- Option C:** Gauss is the non-SI CGS unit of magnetic flux density ($1 \text{ T} = 10^4 \text{ G}$).
- Option D:** Henry (H) is the SI unit of electrical self-inductance and mutual inductance.

Question #148 Key: (B)PHYSICS
11. Electromagnetic Induction

An operating AC generator can stall and stop abruptly when:

CORE CONCEPT & DERIVATION

Lenz's law dictates that an induced current always flows in such a direction that its magnetic effect opposes the mechanical motion that produced it.

Formula / Rule / Reaction:

$$\tau_{net} = \tau_{applied} - \tau_{counter} = I\alpha$$

Solution:

- When current is drawn from an operating generator, the magnetic force on the armature conductors creates a counter-torque (back torque) opposing rotation.
- If electrical load increases to the point where this counter-torque exceeds the driving torque supplied by the prime mover, angular deceleration occurs and the generator stalls.

Why other options are incorrect:

- Option A:** In an operating generator, internal induced EMF drives the current, not an external opposing voltage.
- Option C:** High coil resistance generates thermal energy, but thermal resistance alone does not create opposing mechanical torque.
- Option D:** Moment of inertia is a fixed geometric property of the rotor that does not suddenly drop to stop rotation.

Question #149 Key: (B)PHYSICS
13. Electronics

The output current delivered to a load resistor by a single-diode half-wave rectifier is charac...

CORE CONCEPT & DERIVATION

A semiconductor diode conducts current primarily during forward bias and blocks current during reverse bias.

Formula / Rule / Reaction:

$$I_{out}(t) = \begin{cases} I_0 \sin(\omega t) & 0 \leq \omega t < \pi \quad (\text{Forward Bias}) \\ 0 & \pi \leq \omega t < 2\pi \quad (\text{Reverse Bias}) \end{cases}$$

Solution:

- During positive half-cycles of the AC input, the diode is forward-biased and conducts current through the load in a single direction.
- During negative half-cycles, the diode is reverse-biased and blocks current.
- The resulting output consists of series pulses traveling in only one direction, which defines a pulsating unidirectional current.

Why other options are incorrect:

- Option A:** The output is not alternating because current never reverses its direction through the load.
- Option C:** Current flows during the conducting half-cycle, so it is not zero at all times.
- Option D:** Pure smooth DC requires a filter capacitor to smooth the ripple voltage; a lone rectifier diode yields pulsating DC.

Question #150 Key: (A)PHYSICS
13. Electronics

The dynamic forward resistance of a full-wave rectifier circuit during operational conduction i...

CORE CONCEPT & DERIVATION

Full-wave rectification utilizes both halves of the input AC cycle, providing continuous power transfer, higher average current delivery, and reduced effective internal source impedance.

Formula / Rule / Reaction:

$$I_{dc}(\text{full-wave}) = \frac{2I_0}{\pi} = 2I_{dc}(\text{half-wave}) \implies R_{\text{effective}} = \frac{V_{dc}}{I_{dc}} < R_{\text{half-wave}}$$

Solution:

- A full-wave rectifier delivers double the average output current and operates with significantly higher rectification efficiency (81.2% versus 40.6% for half-wave).
- Because conduction occurs during both halves of the input cycle, the effective internal source impedance opposing current flow over a complete cycle is lower than in a half-wave rectifier.

Why other options are incorrect:

- Option B:** Greater effective resistance would reduce conduction efficiency and current delivery, which contradicts the superior performance of full-wave rectifiers.
- Option C:** Equal resistance would imply identical current delivery and efficiency.
- Option D:** While lower, the diode junction resistance is not negligible.

Question #151 Key: (B)PHYSICS
14. Dawn of Modern Physics

In the photoelectric effect, an emitted photoelectron will possess maximum kinetic energy when ...

CORE CONCEPT & DERIVATION

Einstein's photoelectric equation relates the maximum kinetic energy of ejected electrons to the frequency and wavelength of incident electromagnetic radiation.

Formula / Rule / Reaction:

$$K_{\text{max}} = hf - \Phi = \frac{hc}{\lambda} - \Phi$$

Solution:

- The energy of an incident photon is inversely proportional to its wavelength ($E = hc/\lambda$).
- A shorter wavelength corresponds to a higher photon energy.
- When this higher energy photon strikes the metal surface, the excess energy transferred beyond the work function (Φ) appears as maximum kinetic energy of the emitted photoelectron.

Why other options are incorrect:

- Option A:** A long wavelength corresponds to lower photon energy, resulting in reduced kinetic energy or no emission if below threshold.
- Option C:** Low frequency corresponds to lower photon energy, decreasing kinetic energy.
- Option D:** Circular polarization alters the orientation of the electric field vector but does not increase the quantum energy of individual photons.

Question #152 Key: (C)PHYSICS
13. Electronics

The electrical process of converting alternating current (AC) into direct current (DC) is termed...

CORE CONCEPT & DERIVATION

Rectification is the conversion of bidirectional alternating current into unidirectional direct current using non-linear circuit elements such as semiconductor diodes.

Formula / Rule / Reaction:

$$\text{AC Input (Bidirectional)} \xrightarrow{\text{Diode Circuit}} \text{Pulsating DC Output (Unidirectional)}$$

Solution:

- Diodes allow electric charge to flow freely in the forward direction while presenting high resistance in the reverse direction.
- This unidirectional conduction converts alternating current into pulsating direct current, a process defined as rectification.

Why other options are incorrect:

- Option A:** Magnification refers to an optical increase in the apparent visual size of an object.
- Option B:** Amplification is the process of increasing the amplitude or power of a signal without altering its waveform.
- Option D:** Resolution is the capability of an optical or measurement system to distinguish closely spaced points.

Question #153 Key: (B)PHYSICS
14. Dawn of Modern Physics

In electron-positron pair annihilation, two gamma-ray photons are produced and travel in diamet...

CORE CONCEPT & DERIVATION

Pair annihilation involves the mutual destruction of a particle and its antiparticle, converting their total rest mass and kinetic energy into high-energy electromagnetic radiation.

Formula / Rule / Reaction:

$$\vec{p}_{\text{initial}} = \vec{p}_{e^-} + \vec{p}_{e^+} \approx 0 \implies \vec{p}_{\text{final}} = \vec{p}_{\gamma 1} + \vec{p}_{\gamma 2} = 0 \implies \vec{p}_{\gamma 1} = -\vec{p}_{\gamma 2}$$

Solution:

- In the center-of-mass frame where the electron and positron annihilate essentially at rest, the total initial linear momentum is zero.
- Because a single photon carries non-zero linear momentum ($p = h/\lambda$), a single photon cannot be emitted alone without violating momentum conservation.
- Therefore, at least two photons must be emitted with equal magnitudes of momentum in opposite directions so that their vector sum remains zero.

Why other options are incorrect:

- Option A:** Energy conservation determines the total frequency and wavelength of the emitted photons, but does not dictate opposite directional trajectories.
- Option C:** Charge is conserved because the initial net charge is zero ($-e + e = 0$), and photons carry no charge.
- Option D:** Mass-energy equivalence governs the numerical conversion of mass into radiant energy, not the collinear opposing directions.

Question #154 Key: (C)PHYSICS
15. Atomic Spectra

The electromagnetic thermal radiation emitted by warm-blooded mammals lies predominantly in whi...

CORE CONCEPT & DERIVATION

According to Wien's displacement law, the peak wavelength of blackbody radiation emitted by an object is inversely proportional to its absolute thermodynamic temperature.

Formula / Rule / Reaction:

$$\lambda_{\text{max}} \cdot T = b \approx 2.898 \times 10^{-3} \text{ m} \cdot \text{K}$$

Solution:

- Normal mammalian core body temperature is approximately $37^\circ\text{C} = 310 \text{ K}$.
- Substitute this temperature into Wien's displacement equation:
- $$\lambda_{\text{max}} = \frac{2.898 \times 10^{-3} \text{ m} \cdot \text{K}}{310 \text{ K}} \approx 9.35 \times 10^{-6} \text{ m} = 9.35 \mu\text{m}$$
- This wavelength falls within the thermal infrared region of the electromagnetic spectrum.

Why other options are incorrect:

- Option A:** Thermal emission in the visible spectrum requires temperatures exceeding 800 K (red hot).
- Option B:** Ultraviolet emission requires extremely hot surfaces exceeding several thousand Kelvin (e.g., the Sun).
- Option D:** X-rays require million-Kelvin thermal plasmas or high-energy electron decelerations.

Question #155 Key: (D)PHYSICS
12. Alternating Current

Which of the following electromagnetic photons travels with the greatest speed in a vacuum?

CORE CONCEPT & DERIVATION

In classical and relativistic electrodynamics, all electromagnetic waves propagate through a vacuum at an invariant fundamental constant speed (c), regardless of their frequency or wavelength.

Formula / Rule / Reaction:

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \approx 3.00 \times 10^8 \text{ m/s}$$

Solution:

- The propagation speed of electromagnetic radiation in a vacuum depends only on the permittivity (ϵ_0) and permeability (μ_0) of free space.
- Gamma rays, visible light, and infrared radiation differ in frequency and photon energy, but they all travel at the same velocity c in a vacuum.

Why other options are incorrect:

- Option A:** Gamma photons have the highest frequency and energy, but not a higher speed in a vacuum.
- Option B:** Visible light photons travel at c , identical to all other electromagnetic photons.
- Option C:** Infrared photons possess longer wavelengths, but propagate at c in free space.

Question #156 Key: (C)PHYSICS
02. Force & Motion

The net vector displacement of a moving body divided by the total time elapsed during motion is...

CORE CONCEPT & DERIVATION

Average velocity is a vector quantity defined as the total displacement vector divided by the total time interval taken to complete that displacement.

Formula / Rule / Reaction:

$$\vec{v}_{\text{avg}} = \frac{\Delta \vec{d}}{\Delta t}$$

Solution:

- By definition, the quotient of total net displacement and total elapsed time is the average velocity.

Why other options are incorrect:

- Option A:** Instantaneous velocity is the limiting value of displacement over an infinitesimally small time interval ($\lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{d}}{\Delta t}$).
- Option B:** Uniform velocity refers to motion where velocity remains constant in both magnitude and direction over time.
- Option D:** Variable velocity describes motion where speed or direction changes continuously.

Question #157 Key: (B)PHYSICS
16. Nuclear Physics

The radioactive half-life ([Formula]) of an unstable radioisotope specifies the:

CORE CONCEPT & DERIVATION

Radioactive decay is a stochastic first-order process where the rate of disintegration is directly proportional to the number of radioactive nuclei present.

Formula / Rule / Reaction:

$$N(t) = N_0 \left(\frac{1}{2}\right)^{t/T_{1/2}} \implies T_{1/2} = \frac{\ln 2}{\lambda} \approx \frac{0.693}{\lambda}$$

Solution:

- Half-life is defined as the time interval required for one-half of the unstable radioactive nuclei in a sample to undergo decay into daughter nuclei.

Why other options are incorrect:

- Option A:** The complete decay of an entire sample requires infinite time due to the asymptotic exponential nature of decay.
- Option C:** Half-life applies to all modes of nuclear decay, including beta emission, positron decay, and electron capture.
- Option D:** Daughter nuclei may themselves be stable or radioactive; half-life measures parent nucleus decay.

Question #158 Key: (D)PHYSICS
13. Electronics

In a solid metallic electrical conductor, electric current is transported by the directed motion...

CORE CONCEPT & DERIVATION

In metallic lattices, valence electrons dissociate from individual atoms to form a delocalized conduction electron gas that drifts under the influence of an applied electric field.

Formula / Rule / Reaction:

$$I = nAv_d e$$

Solution:

- Positive atomic cores remain fixed at regular lattice positions and do not move through the solid.
- When an external electric potential is applied, delocalized conduction electrons drift toward the positive terminal, generating the electric current.

Why other options are incorrect:

- Option A:** Protons are bound inside atomic nuclei within the crystal lattice and do not act as mobile charge carriers.
- Option B:** Ions serve as charge carriers in molten salts, solutions, and ionized gases, but not in solid metals.
- Option C:** Holes act as charge carriers in p-type semiconductors, not in pure metallic conductors.

Question #159 Key: (A)PHYSICS
15. Atomic Spectra

The shortest possible photon wavelength in the emission spectrum of atomic hydrogen is associated with...

CORE CONCEPT & DERIVATION

The photon wavelength in atomic hydrogen transitions is governed by the Rydberg formula, where the shortest wavelength corresponds to the maximum possible energy transition.

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \implies \lambda_{\text{shortest}} \text{ when } n_1 = 1 \text{ and } n_2 = \infty$$

Solution:

- Transitions terminating at the ground state ($n_1 = 1$, the Lyman series) involve the largest energy gaps in the hydrogen atom.

- The series limit of the Lyman series occurs when an electron drops from $n_2 = \infty$ to $n_1 = 1$:

$$\frac{1}{\lambda_{\text{min}}} = R_H \left(\frac{1}{1^2} - 0 \right) = R_H \implies \lambda_{\text{min}} = \frac{1}{R_H} \approx 91.2 \text{ nm}$$

- Because this transition represents the largest possible energy drop, it produces the shortest wavelength in the entire hydrogen spectrum.

Why other options are incorrect:

- Option B:** The Balmer series terminates at $n_1 = 2$, with its shortest wavelength at 364.6 nm.
- Option C:** The Brackett series terminates at $n_1 = 4$, with its shortest wavelength at 1458 nm.
- Option D:** The Paschen series terminates at $n_1 = 3$, with its shortest wavelength at 820.4 nm.

Question #160 Key: (D)PHYSICS
16. Nuclear Physics

Which of the following types of electromagnetic radiation cannot be generated by electron transitions...

CORE CONCEPT & DERIVATION

Electromagnetic radiation is classified by its physical mechanism of origin: atomic electron transitions involve orbital shells, whereas gamma radiation originates from transitions within the atomic nucleus.

Formula / Rule / Reaction:

$$\text{Gamma Rays: } \Delta E_{\text{nuclear}} \sim \text{keV to MeV (Nuclear De-excitation / Decay)}$$

Solution:

- Infrared, visible, and ultraviolet rays are produced by valence electron transitions between outer atomic shells.
- Characteristic X-rays are produced when inner-shell electrons (such as K or L shells) are displaced in heavy atoms.
- Gamma rays are emitted exclusively from transitions between nuclear energy states during radioactive decay, not from orbital electron rearrangements.

Why other options are incorrect:

- Option A:** Infrared radiation is emitted during low-energy outer-shell electronic transitions in hydrogen (e.g., Paschen and Brackett series).
- Option B:** Ultraviolet radiation is emitted during electronic transitions to the ground state (e.g., Lyman series).
- Option C:** X-rays are produced by inner-shell atomic electron transitions in high-Z target anodes.

Question #161 Key: (B)PHYSICS
16. Nuclear Physics

The rate of spontaneous nuclear radioactive decay does not depend on which of the following par...

CORE CONCEPT & DERIVATION

Radioactivity is an intrinsic, spontaneous nuclear process governed by strong and weak nuclear forces, which are independent of external thermal or environmental conditions.

Formula / Rule / Reaction:

$$-\frac{dN}{dt} = \lambda N \quad (\lambda \text{ is a nuclear constant independent of } T, P)$$

Solution:

- Nuclear binding forces operate on energy scales of millions of electron volts (MeV), whereas ambient temperature and pressure influence atomic interactions at scales of only fractions of an electron volt (eV).
- Consequently, altering temperature or pressure has no measurable effect on the decay rate or decay constant λ .

Why other options are incorrect:

- Option A:** The decay rate (dN/dt) is directly proportional to the number of parent atoms present.
- Option C:** The chemical nature (isotopic identity) determines nuclear stability and the value of λ .
- Option D:** The total number of remaining undecayed atoms decreases exponentially with time.

Question #162 Key: (D)PHYSICS
16. Nuclear Physics

Which of the following is not an accepted physical unit of radioactivity?

CORE CONCEPT & DERIVATION

Radioactivity is quantified as the activity (disintegration rate) of a radionuclide, defined as the number of nuclear decays occurring per unit time.

Formula / Rule / Reaction:

$$1 \text{ Bq} = 1 \text{ disintegration per second}; \quad 1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$$

Solution:

- Becquerel, Curie, and decays per second are standard units used to measure nuclear activity.
- Tesla/m² is dimensionally equivalent to magnetic flux density divided by area, which has no relationship to nuclear decay rates.

Why other options are incorrect:

- Option A:** Becquerel is the official SI derived unit of radioactivity.
- Option B:** Curie is the classic historical unit of radioactivity.
- Option C:** Decays per second is the fundamental base definition of a Becquerel.

Question #163 Key: (A)PHYSICS
16. Nuclear Physics

The Curie ([Formula]) is a measurement unit of:

CORE CONCEPT & DERIVATION

The Curie is a traditional unit of radioactivity named in honor of Marie and Pierre Curie, originally defined as the activity of one gram of radium-226.

Formula / Rule / Reaction:

$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ disintegrations/second} = 3.7 \times 10^{10} \text{ Bq}$$

Solution:

- The Curie measures the activity or disintegration rate of a radioactive source.

Why other options are incorrect:

- Option B:** Temperature is measured in Kelvin, Celsius, or Fahrenheit.
- Option C:** Half-life is a time interval measured in seconds, hours, or years.
- Option D:** The Curie temperature (or Curie point) is a temperature threshold for ferromagnetism, but the stand-alone unit 'Curie' (Ci) measures radioactivity.

Question #164 Key: (A)PHYSICS
16. Nuclear Physics

Which of the following heavy elements possesses stable, non-radioactive isotopes in nature?

CORE CONCEPT & DERIVATION

In the periodic table, all chemical elements with atomic numbers $Z > 82$ (beyond lead) possess unstable nuclei with no stable isotopes.

Formula / Rule / Reaction:

$\text{Lead } (Z = 82): \text{Stable isotopes include } ^{204}\text{Pb}, ^{206}\text{Pb}, ^{207}\text{Pb}, \text{ and } ^{208}\text{Pb}$

Solution:

- Lead (atomic number 82) has stable isotopes and represents the end product of the uranium, thorium, and actinium natural radioactive decay series.
- Plutonium ($Z = 94$), radium ($Z = 88$), and protactinium ($Z = 91$) are all radioactive and decay spontaneously over time.

Why other options are incorrect:

- Option B:** Plutonium is a synthetic transuranic element with exclusively radioactive isotopes.
- Option C:** Radium is an alpha-emitting alkaline earth radioisotope.
- Option D:** Protactinium is an actinide element that is radioactive throughout all known isotopes.

Question #165 Key: (A)PHYSICS
14. Dawn of Modern Physics

In physics, when a particle of matter collides with its corresponding antiparticle particle, they...

CORE CONCEPT & DERIVATION

Because a particle and its antiparticle possess equal and opposite electric charges, the net electric charge of the system prior to annihilation is identically zero.

Formula / Rule / Reaction:

$$e^- + e^+ \rightarrow 2\gamma \quad (q_{\text{initial}} = -e + e = 0 \Rightarrow q_{\text{final}} = 0)$$

Solution:

- By the fundamental law of conservation of electric charge, the total charge of all resultant particles must equal the initial net charge (zero).
- Electron-positron annihilation yields gamma-ray photons, which have zero electric charge.

Why other options are incorrect:

- Option B:** Producing positive charge would violate the conservation of electric charge.
- Option C:** Producing negative charge would violate the conservation of electric charge.
- Option D:** 'Dual mass' is not a recognized physical concept; rest mass is converted into radiant energy according to $E = mc^2$.

Question #166 Key: (A)PHYSICS
15. Atomic Spectra

The longest photon wavelength observed in the Balmer emission series of atomic hydrogen is:

CORE CONCEPT & DERIVATION

The longest wavelength in any spectral series corresponds to the transition between adjacent quantized levels with the minimum energy change ($\Delta n = 1$).

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \Rightarrow \text{Balmer } H_\alpha \text{ line: } n_1 = 2, n_2 = 3$$

Solution:

- For the Balmer series, the lower level is $n_1 = 2$.
- The longest wavelength transition originates from the immediately adjacent upper level, $n_2 = 3$:

$$\frac{1}{\lambda_{\text{max}}} = R_H \left(\frac{1}{2^2} - \frac{1}{3^2} \right) = R_H \left(\frac{1}{4} - \frac{1}{9} \right) = R_H \left(\frac{9-4}{36} \right) = \frac{5}{36} R_H$$

- Invert to solve for wavelength:

$$\lambda_{\text{max}} = \frac{36}{5R_H}$$

Why other options are incorrect:

- Option B:** $\frac{36}{7R_H}$ would correspond to $n_2 = 4$, which is the second line (H_β) with a shorter wavelength.
- Option C:** $\frac{36}{11R_H}$ does not match any valid integer transition in the series.
- Option D:** $\frac{36}{13R_H}$ does not correspond to the longest wavelength transition.

Question #167 Key: (B)PHYSICS
15. Atomic Spectra

The shortest photon wavelength in the Lyman series of atomic hydrogen (the series limit) is equ...

CORE CONCEPT & DERIVATION

The series limit of a spectral line series occurs when an electron transitions from infinity (ionization state, $n_2 = \infty$) to the base level of that series.

Formula / Rule / Reaction:

$$\frac{1}{\lambda_{\text{min}}} = R_H \left(\frac{1}{n_1^2} - \frac{1}{\infty^2} \right) \Rightarrow \text{Lyman Series: } n_1 = 1$$

Solution:

- For the Lyman series limit, substitute $n_1 = 1$ and $n_2 = \infty$:

$$\frac{1}{\lambda_{\text{min}}} = R_H \left(\frac{1}{1^2} - 0 \right) = R_H$$

- Taking the reciprocal yields:

$$\lambda_{\text{min}} = \frac{1}{R_H}$$

Why other options are incorrect:

- Option A:** R_H is the wavenumber ($\bar{\nu} = 1/\lambda$), not the wavelength itself.
- Option C:** $3R_H$ has units of inverse meters and incorrect magnitude.
- Option D:** $\frac{5}{R_H}$ does not match the mathematical limit of the Lyman series.

Question #168 Key: (A)PHYSICS
16. Nuclear Physics

For the clinical treatment of deep-seated malignant cancers in radiation therapy, the primary r...

CORE CONCEPT & DERIVATION

Cobalt-60 is a synthetic radioisotope that undergoes beta decay followed by the emission of two penetrating gamma-ray photons (1.17 MeV and 1.33 MeV), making it an effective radiation source for external beam teletherapy.

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

- Cobalt-60 is widely used in external beam teletherapy units to deliver targeted ionizing radiation that damages the DNA of malignant cancer cells.

Why other options are incorrect:

- Option B:** Iodine-131 (not I-126) is used clinically for thyroid ablation.
- Option C:** Sodium-24 (not Na-15, which is non-existent) is used as a medical tracer for circulatory investigations.
- Option D:** Lead-207 is a stable, non-radioactive isotope used for radiation shielding, not as an active therapeutic source.

Question #169 Key: (D)PHYSICS
02. Force & Motion

The velocity-time graph of a body starting from rest and moving with uniform linear acceleration...

CORE CONCEPT & DERIVATION

For one-dimensional motion with constant acceleration starting from rest, velocity is directly proportional to elapsed time.

Formula / Rule / Reaction:

$$v = u + at, \quad u = 0 \implies v = at \quad (y = mx)$$

Solution:

- Because the body starts from rest, at time $t = 0$, velocity is $v = 0$.
- Under uniform acceleration, the slope of the line ($a = dv/dt$) is constant.
- The resulting plot of v versus t forms a straight line passing directly through the origin $(0, 0)$.

Why other options are incorrect:

- **Option A:** A straight line not passing through the origin represents motion with a non-zero initial velocity ($u \neq 0$).
- **Option B:** A line parallel to the time axis represents zero acceleration (constant velocity).
- **Option C:** A line parallel to the velocity axis would imply infinite acceleration, which is physically impossible.

Question #170 Key: (C)PHYSICS
02. Force & Motion

A projectile is launched at an angle of [Formula] with the horizontal, producing a horizontal range...

CORE CONCEPT & DERIVATION

The horizontal range of a projectile on level ground is identical for complementary angles of projection (angles that sum to 90°).

Formula / Rule / Reaction:

$$R = \frac{v_0^2 \sin(2\theta)}{g}, \quad \sin[2(90^\circ - \theta)] = \sin(180^\circ - 2\theta) = \sin(2\theta)$$

Solution:

- The first projectile is launched at an angle $\theta_1 = 45^\circ$ with the horizontal.
- The second projectile is launched at an angle of 45° with the vertical, which corresponds to an angle with the horizontal of $\theta_2 = 90^\circ - 45^\circ = 45^\circ$.
- Because the launch angle with the horizontal is identical in both cases (45°), the ranges must be equal: $R_1 = R_2$.

Why other options are incorrect:

- **Option A:** $R_2 = 2R_1$ is incorrect because the two angles are complementary and identical.
- **Option B:** $R_1 = 2R_2$ is incorrect because the projection angles are identical.
- **Option D:** Unequal proportions do not apply to identical launch angles.

Question #171 Key: (B)PHYSICS
03. Work & Energy

A cyclist comes to a skidding stop over a distance of [Formula]. During this braking process, ...

CORE CONCEPT & DERIVATION

Work done by a constant force is defined as the scalar product of the force vector and the displacement vector.

Formula / Rule / Reaction:

$$W = \vec{F} \cdot \vec{d} = F \cdot d \cdot \cos \theta$$

Solution:

- The braking force acts in the direction opposite to the displacement, meaning $\theta = 180^\circ$.
- Calculate the work done:
- $$W = (200 \text{ N}) \times (10 \text{ m}) \times \cos(180^\circ) = 2000 \times (-1) = -2000 \text{ J}$$
- The negative sign indicates that kinetic energy is removed from the bicycle.

Why other options are incorrect:

- **Option A:** -1800 J is mathematically incorrect.
- **Option C:** $+2000 \text{ J}$ ignores the negative sign resulting from the opposing direction of friction ($\cos 180^\circ = -1$).
- **Option D:** $+1900 \text{ J}$ is incorrect in both magnitude and sign.

Question #172 Key: (B)PHYSICS
05. Waves

The total mechanical energy of an undamped simple harmonic oscillator remains constant throughout...

CORE CONCEPT & DERIVATION

In simple harmonic motion, total energy continuously exchanges between kinetic energy and elastic potential energy, while their sum remains constant.

Formula / Rule / Reaction:

$$E_{\text{total}} = \frac{1}{2}kx^2 + \frac{1}{2}mv^2 = \frac{1}{2}kx_0^2$$

Solution:

- At the extreme positions ($x = \pm x_0$), the instantaneous velocity of the oscillator drops to zero ($v = 0$), meaning kinetic energy is zero.
- Consequently, all energy is stored as potential energy, making potential energy maximum at the extremes:

$$\text{P.E.}_{\text{max}} = \frac{1}{2}kx_0^2$$

Why other options are incorrect:

- **Option A:** Kinetic energy is zero at the extreme positions because the oscillator momentarily comes to rest before reversing direction.
- **Option C:** At the mean position ($x = 0$), potential energy is zero while kinetic energy reaches its maximum value.
- **Option D:** Potential energy is zero at the mean position, not maximum.

Question #173 Key: (B)PHYSICS
05. Waves

Transverse waves travel along a stretched string of length [Formula] with a speed of [Formula] ...

CORE CONCEPT & DERIVATION

A string fixed at both ends forms standing waves with resonant frequencies that are integer multiples of the fundamental frequency.

Formula / Rule / Reaction:

$$f_n = n \cdot f_1 = n \left(\frac{v}{2L} \right), \quad n = 1, 2, 3, \dots$$

Solution:

- Calculate the fundamental frequency ($n = 1$):

$$f_1 = \frac{v}{2L} = \frac{24 \text{ m/s}}{2 \times 6.0 \text{ m}} = \frac{24}{12} = 2 \text{ Hz}$$

- The resonant harmonic frequencies are integer multiples of f_1 :

$$f_1 = 2 \text{ Hz}, \quad f_2 = 2 \times 2 = 4 \text{ Hz}, \quad f_3 = 3 \times 2 = 6 \text{ Hz}$$

- Therefore, the string resonates at 2 Hz, 4 Hz, 6 Hz.

Why other options are incorrect:

- Option A:** 1 Hz would require a string length of 12 m.
- Option C:** 3 Hz would require a wave speed of 36 m/s.
- Option D:** 5 Hz is not an integer multiple of the 2 Hz fundamental mode.

Question #174 Key: (C)PHYSICS
05. Waves

The apparent shift in the observed frequency of a wave caused by relative motion between the so...

CORE CONCEPT & DERIVATION

The Doppler effect describes the observed change in wave frequency when the source of waves, the observer, or both move relative to the medium of propagation.

Formula / Rule / Reaction:

$$f' = f \left(\frac{v \pm v_o}{v \mp v_s} \right)$$

Solution:

- When a sound source moves toward an observer, wave crests are compressed, producing an apparent increase in pitch (frequency).
- When moving apart, the waves stretch out, producing a lower perceived frequency. This phenomenon is called the Doppler effect.

Why other options are incorrect:

- Option A:** The Zeeman effect is the splitting of atomic spectral lines in the presence of an external static magnetic field.
- Option B:** The Stark effect is the splitting of atomic spectral lines in an external electric field.
- Option D:** The Compton effect is the increase in wavelength of X-rays or gamma rays scattered by electrons.

Question #175 Key: (A)PHYSICS
05. Waves

A simple pendulum with a bob of mass [Formula] has a period of oscillation [Formula]. If the b...

CORE CONCEPT & DERIVATION

For small angular displacements, the period of a simple pendulum depends only on its effective length and the local acceleration due to gravity, and is completely independent of the mass of the bob.

Formula / Rule / Reaction:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Solution:

- The formula for the time period contains no mass term (m).
- Replacing the bob with a mass of $3m$ does not alter length L or gravitational acceleration g .
- Therefore, the period remains unchanged at T .

Why other options are incorrect:

- Option B:** $3T$ assumes a direct linear dependence on mass, which does not apply to a pendulum.
- Option C:** $T/3$ assumes an inverse dependence on mass.
- Option D:** $2T$ is incorrect because mass does not influence the period of a simple pendulum.

Question #176 Key: (C)PHYSICS
05. Waves

A wave propagates with velocity [Formula], time period [Formula], and frequency [Formula]. W...

CORE CONCEPT & DERIVATION

Frequency is defined as the number of complete oscillations or wave cycles passing a fixed point per unit time, which is the reciprocal of the time period.

Formula / Rule / Reaction:

$$f = \frac{1}{T} \iff f \cdot T = 1$$

Solution:

- By fundamental definition, frequency and period are inverse quantities: $f = 1/T$.

Why other options are incorrect:

- Option A:** $T = vf$ is dimensionally inconsistent.
- Option B:** Adding velocity and time period violates dimensional homogeneity.
- Option D:** $T = v/T$ is algebraically and dimensionally incorrect.

Question #177 Key: (D)ENGLISH
03. Parts of Speech, Prepositions & Modifiers

The word 'Cowardice' is classified grammatically as a/an:

CORE CONCEPT & DERIVATION

An abstract noun designates an intangible concept, quality, emotion, or state that cannot be perceived through the five physical senses.

Formula / Rule / Reaction:

Abstract Noun = Intangible Quality, State, or Condition (Non-physical entity)

Solution:

- 'Cowardice' denotes the psychological quality or state of lacking courage.
- Because it describes an intangible concept rather than a concrete material object, it is an abstract noun.

Why other options are incorrect:

- **Option A:** A common noun refers to tangible classes of people, places, or things (e.g., city, soldier).
- **Option B:** A proper noun is the capitalized name of a specific individual, place, or institution.
- **Option C:** 'Cowardice' is an uncountable (mass) noun; it cannot be pluralized into 'cowardices' in standard English.

Question #178 Key: (C)ENGLISH
03. Parts of Speech, Prepositions & Modifiers

The noun 'Bridegroom' is an example of which grammatical gender category?

CORE CONCEPT & DERIVATION

Grammatical gender classifies nouns denoting living beings according to biological sex: masculine, feminine, common, or neuter.

Formula / Rule / Reaction:

Masculine: Bridegroom $\longleftrightarrow$ Feminine: Bride

Solution:

- A bridegroom is a man on his wedding day or just before it.
- Because it refers specifically to a male individual, it belongs to the masculine gender.

Why other options are incorrect:

- **Option A:** Neuter gender refers to inanimate objects without biological sex (e.g., table, stone).
- **Option B:** Common gender denotes words that can apply to either males or females (e.g., doctor, cousin).
- **Option D:** The corresponding feminine noun is 'bride'.

Question #179 Key: (B)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Identify the sentence structure type of the following sentence: 'I waited for the bus, but it W...

CORE CONCEPT & DERIVATION

A compound sentence contains at least two independent clauses joined by a coordinating conjunction (such as FANBOYS: for, and, nor, but, or, yet, so) or a semicolon.

Formula / Rule / Reaction:

Independent Clause 1 + Coordinating Conjunction (but) + Independent Clause 2 = Compound

Solution:

- Clause 1: 'I waited for the bus' (complete independent thought).
- Clause 2: 'it was late' (complete independent thought).
- The two clauses are joined by the coordinating conjunction 'but', satisfying the definition of a compound sentence.

Why other options are incorrect:

- **Option A:** A simple sentence consists of only one independent clause.
- **Option C:** A complex sentence requires at least one independent clause and one dependent (subordinate) clause.
- **Option D:** A compound-complex sentence requires at least two independent clauses and one dependent clause.

Question #180 Key: (C)ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Choose the correct preposition to complete the sentence: 'We can drive _____ the tunnel.'

CORE CONCEPT & DERIVATION

The preposition 'through' is used to indicate movement into one side of an enclosed three-dimensional passage and out the other side.

Formula / Rule / Reaction:

Preposition of Motion: 'Through' indicates passage from one end of an enclosed structure to the

Solution:

- A tunnel is an enclosed, hollow passage.
- Traveling from one end of a tunnel to the other requires the preposition 'through'.

Why other options are incorrect:

- **Option A:** 'Drive by' means to pass adjacent to the tunnel without entering it.
- **Option B:** 'At' denotes a static point location, not traversal through an enclosed passage.
- **Option D:** 'Drive into' indicates entering the tunnel, but omits the concept of passing all the way through to the other side.

Question #181 Key: (D)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Select the grammatically correct passive voice transformation of the active sentence: 'She need...

CORE CONCEPT & DERIVATION

When converting an active sentence containing an infinitive ('to clean') into passive voice, the main verb tense is preserved while the infinitive becomes 'to be + past participle'.

Formula / Rule / Reaction:

Active: Subject + needs to + V_1 + Object $\Rightarrow$ Passive: Object + needs to be + V_3 + by Subject

Solution:

- The original sentence is in the present tense ('needs').
- The direct object 'the room' moves to the subject position.
- The infinitive 'to clean' becomes passive: 'to be cleaned'.
- Retaining the present tense gives: 'The room needs to be cleaned by her.'

Why other options are incorrect:

- **Option A:** 'Needed' incorrectly changes the present tense to the past tense, and 'to clean' is left in the active voice.
- **Option B:** 'Needed' incorrectly shifts the present tense of 'needs' to the past tense.
- **Option C:** 'To be clean' uses an adjective rather than the required past participle 'cleaned'.

Question #182 Key: (B)ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

What figure of speech is employed in the sentence: 'He is the black sheep of the class.'?

CORE CONCEPT & DERIVATION

A metaphor is a figure of speech that makes a direct figurative comparison between two unrelated entities without using 'like' or 'as'.

Formula / Rule / Reaction:

Direct Assertion: A is B (without 'like' or 'as') $\Rightarrow$ Metaphor

Solution:

- The sentence directly identifies the student as the 'black sheep' (an odd or disreputable member of a group).
- Because the comparison is asserted directly without using comparison words such as 'like' or 'as', it is a metaphor.

Why other options are incorrect:

- **Option A:** A simile requires explicit comparison words such as 'like' or 'as' (e.g., 'He is like a black sheep').
- **Option C:** Alliteration involves the repetition of initial consonant sounds across neighboring words.
- **Option D:** Hyperbole is intentional exaggeration used for rhetorical emphasis.

Question #183 Key: (D)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Complete the sentence using the correct conditional form: 'Had I studied very well, I

CORE CONCEPT & DERIVATION

This sentence is an inverted third conditional expressing a hypothetical, counterfactual condition in the past.

Formula / Rule / Reaction:

Had + Subject + $V_3 \iff$ If + Subject + had + V_3 , Main Clause: Subject + would have been

Solution:

- The introductory clause 'Had I studied' is an inverted past perfect conditional clause.
- In a third conditional sentence, the dependent past perfect clause requires 'would have been' in the passive main clause.

Why other options are incorrect:

- **Option A:** 'Was' is simple past indicative and cannot complete a counterfactual past conditional.
- **Option B:** 'Were' expresses a present unreal condition (second conditional), which does not match the past perfect 'Had I studied'.
- **Option C:** 'Will have been' is a future perfect construction and does not agree with past counterfactual clauses.

Question #184 Key: (D)ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Choose the grammatically correct pronoun to complete the sentence: 'My brother and I met an acq...

CORE CONCEPT & DERIVATION

In standard English, the double possessive construction requires a possessive pronoun (or possessive noun with 's) after the preposition 'of'.

Formula / Rule / Reaction:

Noun + of + Absolute Possessive Pronoun (mine, yours, his, hers, ours, theirs)

Solution:

- The phrase 'an acquaintance of ours' indicates 'one of our acquaintances'.
- Idiomatic English grammar requires the absolute possessive pronoun 'ours' following 'of'.

Why other options are incorrect:

- **Option A:** 'Ourselves' is a reflexive or emphatic pronoun, which is ungrammatical following 'an acquaintance of'.
- **Option B:** 'Us' is an objective pronoun; standard English rejects 'an acquaintance of us' in favor of the double possessive.
- **Option C:** 'Our' is a possessive determiner that must precede a noun (e.g., 'our acquaintance'), and cannot stand alone after 'of'.

Question #185 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The vocabulary word 'Adept' means:

CORE CONCEPT & DERIVATION

'Adept' is an adjective originating from Latin *adeptus*, describing an individual who is highly skilled, thoroughly trained, or proficient at a particular task.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- 'Proficient' means competent, skilled, and practiced, making it an exact synonym for 'adept'.

Why other options are incorrect:

- Option B:** 'Naive' means lacking worldly experience or judgment, which is unrelated.
- Option C:** 'Friend' is an ally or companion.
- Option D:** 'Abode' refers to a dwelling place or residence.

Question #186 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The vocabulary word 'Frugality' means:

CORE CONCEPT & DERIVATION

'Frugality' is a noun denoting prudence in the expenditure of money and avoidance of wasteful consumption.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Being economical involves exercising thrift and careful management of resources, which matches the definition of frugality.

Why other options are incorrect:

- Option B:** 'Enthusiasm' denotes passionate interest or eagerness.
- Option C:** 'Foolishness' denotes a lack of good sense or wisdom.
- Option D:** 'Effective' means successfully producing a desired result.

Question #187 Key: (C)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The antonym for the word 'Chaotic' is:

CORE CONCEPT & DERIVATION

'Chaotic' describes a state of total confusion, unpredictability, and lack of systemic arrangement; its antonym is a word denoting organization and structured harmony.

Formula / Rule / Reaction:Chaotic (Disordered, Disorganized) $\longleftrightarrow$ Antonym: Orderly (Methodical, Structured)**Solution:**

- 'Orderly' means arranged in an organized, neat, and disciplined manner, making it the direct antonym of 'chaotic'.

Why other options are incorrect:

- Option A:** 'Embarrassing' means causing shame or awkwardness.
- Option B:** 'Hectic' means full of frantic activity and chaos, acting as a partial synonym rather than an antonym.
- Option D:** 'Nervous' means anxious or apprehensive.

Question #188 Key: (A)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Choose the grammatically correct indirect speech for the sentence: I said to you, 'What a nice ...'

CORE CONCEPT & DERIVATION

In converting exclamatory sentences to indirect speech, the reporting verb changes to 'exclaimed', exclamatory phrasing converts into an assertive clause, and the present tense shifts to the past tense.

Formula / Rule / Reaction:Direct: Said, 'What a...' $\Rightarrow$ Indirect: Exclaimed that + Subject + Past Verb + Complement**Solution:**

- The reporting verb 'said to you' converts to 'exclaimed'.
- The exclamatory phrase 'What a nice scenery!' is restructured into an assertive clause with past tense: 'that it was a nice scenery'.

Why other options are incorrect:

- Option B:** Retains the present tense 'is' instead of backshifting to the past tense 'was'.
- Option C:** Uses 'told you that' and keeps the direct exclamatory word order, which is ungrammatical.
- Option D:** Distorts word order and syntax.

Question #189 Key: (B)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Choose the grammatically correct sentence:

CORE CONCEPT & DERIVATION

In standard English, double negatives are ungrammatical; a negative auxiliary verb must pair with an assertive or non-negative polarity item like 'ever'.

Formula / Rule / Reaction:

Correct: Negative Auxiliary (haven't) + Non-assertive Adverb (ever)

Solution:

- Option B correctly pairs the negative auxiliary 'haven't' with 'ever' without introducing a redundant negative.

Why other options are incorrect:

- Option A:** Combines 'haven't' with 'never', forming an incorrect double negative.
- Option C:** 'Ever' is not typically used in positive declarative statements of this form.
- Option D:** Uses an ungrammatical triple negative ('haven't ever never').

Question #190 **Key: (C)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Complete the sentence using the correct verb form: 'The child _____ spoken to his parents be...

CORE CONCEPT & DERIVATION

When an action was completed prior to another past event ('before going on the trip'), the past perfect tense ('had + past participle') is required.

Formula / Rule / Reaction:

Subject + had + V_3 (Past Participle) + before + Past Event

Solution:

- The verb 'spoken' is a past participle.
- Because the child is singular and the speaking occurred prior to the past trip, the auxiliary 'had' must be used to form the past perfect tense.

Why other options are incorrect:

- **Option A:** 'Have' violates subject-verb agreement with the singular noun 'child' and expresses present, not past, time.
- **Option B:** 'Will be' requires a present participle ('speaking') to form a continuous tense.
- **Option D:** 'Would' requires a bare infinitive ('speak') rather than the past participle 'spoken'.

Question #191 **Key: (B)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Identify the incorrect underlined word or phrase in the sentence: 'The cause (A) of the car acc...

CORE CONCEPT & DERIVATION

In standard English, the modal auxiliary 'can' cannot be used with a perfect infinitive ('can have been') to express past possibility; 'could have', 'may have', or 'might have' must be used instead.

Formula / Rule / Reaction:

Past Speculation / Possibility: Subject + could / may / might have been (NOT 'can have been')

Solution:

- The modal 'can' denotes present general ability or theoretical possibility.
- When hypothesizing about the cause of a past event, standard grammar requires 'could have been' or 'might have been'.
- Therefore, 'can' is the grammatically incorrect element in the sentence.

Why other options are incorrect:

- **Option A:** 'The cause' correctly serves as the singular noun subject of the sentence.
- **Option C:** 'Have' is correctly used to complete the perfect infinitive following a modal auxiliary.
- **Option D:** 'Malfunctioning' is a participle functioning as an adjective modifying 'brake pads'.

Question #192 **Key: (A)**ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Choose the grammatically correct pronoun to complete the sentence: 'I am as much intelligent as...

CORE CONCEPT & DERIVATION

In formal English, an elliptical comparative clause introduced by 'as' compares two subjects and requires a subject pronoun followed by an implied verb.

Formula / Rule / Reaction:

Subject₁ + Verb + as + Adjective + as + Subject₂ + [Implied Verb]

Solution:

- Expanding the elliptical clause reveals the full structure: 'I am as much intelligent as he [is]'.
- Because the pronoun acts as the subject of the implied verb 'is', the nominative (subject) pronoun 'he' must be used.

Why other options are incorrect:

- **Option B:** 'Himself' is a reflexive pronoun and cannot serve as the subject of the comparative clause.
- **Option C:** 'Him' is an objective pronoun; its use here is an informal colloquialism rejected by prescriptive test standards.
- **Option D:** 'His' is a possessive pronoun and cannot function as a subject pronoun here.

Question #193 **Key: (B)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Read the passage and answer the question: 'Comprehension of medical books is considered as one ...

CORE CONCEPT & DERIVATION

Reading comprehension questions requiring the identification of an exception require evaluating each choice against the explicit text of the passage to spot ungrounded, absolute claims.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The passage states that reading can be viewed as a guessing activity where inferring terminology is a useful skill.
- It does not state that inferring is the 'only' approach used by medical students. Absolute qualifiers such as 'only' misrepresent the author's nuanced argument.
- Therefore, Option B is the statement that is not supported by the passage.

Why other options are incorrect:

- **Option A:** Directly supported by the first sentence of the passage.
- **Option C:** Directly supported by the observation that technical terms make comprehension challenging.
- **Option D:** Directly supported by the final sentence: 'The ability to guess and infer the meanings of unknown terminology might be viewed as a skill that should be developed.'

Question #194 Key: (D)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Read the passage and answer the question: 'People say that certain cancers are protected against...'.

CORE CONCEPT & DERIVATION

Direct inference from an informative text requires identifying the central premise corroborated by stated details without extrapolating unsupported claims.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The passage states that tomatoes help protect against certain cancers and that 'lycopene has been found to be responsible for tomato's and tomato product's ability to prevent certain cancers'.
- This confirms a clear positive correlation between lycopene intake and the prevention of certain types of cancer.

Why other options are incorrect:

- Option A:** The passage notes that lycopene is fat-soluble and absorbed with oil; it does not state that it dissolves rapidly in fruit juice.
- Option B:** Directly contradicts the passage, which attributes cancer-preventative properties to lycopene.
- Option C:** The passage states that oil assists in absorbing lycopene, but does not claim that tomatoes themselves are naturally high in fat.

Question #195 Key: (A)LOGICAL REASONING
04. Argument Evaluation & Ethics

Read the passage below and answer the question: 'The water resources of our country are very mu...'.

CORE CONCEPT & DERIVATION

An inference is evaluated as 'Definitely true' when it directly reflects or logically follows from facts explicitly stated in the source text.

Formula / Rule / Reaction:

Passage Statement: 'We can make full use of our water resources by building dams on rivers...' ⇒ **Definitely True**

Solution:

- The passage states that full use and conservation of water resources can be achieved by building dams on rivers.
- Therefore, the assertion that dam construction is an essential step is directly supported and definitely true.

Why other options are incorrect:

- Option B:** 'Probably true' applies to probable conclusions drawn from indirect evidence; here the statement is directly affirmed.
- Option C:** 'Data is inadequate' applies when the text offers no relevant information, which is not the case here.
- Option D:** 'Probably false' contradicts the explicit endorsement of dam construction in the text.

Question #196 Key: (D)LOGICAL REASONING
04. Argument Evaluation & Ethics

Read the passage below and answer the question: 'The water resources of our country are very mu...'.

CORE CONCEPT & DERIVATION

An inference is evaluated as 'Definitely false' when it directly contradicts facts stated in the source passage.

Formula / Rule / Reaction:

Passage Statement: 'A large portion of our water resources is wasted due to floods...' ⇒ **Flood**

Solution:

- The text identifies floods as a major cause of water resource loss ('A large portion of our water resources is wasted due to floods').
- Claiming that floods add to usable water resources directly contradicts the passage.
- Therefore, the inference is definitely false.

Why other options are incorrect:

- Option A:** The passage states that floods waste water rather than conserving it, so the statement cannot be true.
- Option B:** The statement is directly refuted by the text, not merely probable.
- Option C:** 'Probably false' is used when a statement is likely untrue but lacks direct refutation; here, the text explicitly contradicts it.

Question #197 Key: (A)LOGICAL REASONING
04. Argument Evaluation & Ethics

Read the passage below and answer the question: 'The water resources of our country are very mu...'.

CORE CONCEPT & DERIVATION

In economic contexts, 'capital' refers to financial funds and investment resources available for development.

Formula / Rule / Reaction:

Passage: 'The main reason behind this is the lack of capital...' ⇒ **Lack of Funds**

Solution:

- The author explicitly identifies 'lack of capital' as a primary reason why water resources remain underutilized.
- Because capital refers to financial funds, the statement that the country lacks adequate funds to develop these resources is definitely true.

Why other options are incorrect:

- Option B:** The statement is explicitly supported by the text rather than being merely probable.
- Option C:** The passage provides clear information regarding the lack of capital, so data is adequate.
- Option D:** The statement aligns with the text and is not false.

Question #198 Key: (C)LOGICAL REASONING
08. Letter Series & Coding-Decoding

In a certain code language, the word REMOTE is encrypted as ROTEME. Which original English word...

CORE CONCEPT & DERIVATION

In letter-permutation coding, each letter in the plaintext word is mapped to a specific index position in the encrypted word.

Formula / Rule / Reaction:

Original Positions: [1, 2, 3, 4, 5, 6] $\Rightarrow$ Coded Positions: [1, 4, 3, 2, 5, 6] or pairwise positional shifts

Solution:

- Analyze the transformation from REMOTE to ROTEME:
- Letter 1 (R) remains at index 1: R.
- Letter 2 (E) swaps with Letter 4 (O): position 2 becomes O, position 4 becomes E.
- Letter 3 (M) swaps with Letter 5 (T): position 3 becomes T, position 5 becomes M.
- Letter 6 (E) remains at index 6: E.
- Apply the reverse operation to decrypt the coded word PNIICC (positions 1 to 6: P-N-I-I-C-C):
- Position 1 remains 'P'.
- Position 2 receives the letter from coded position 4 ('I').
- Position 3 receives the letter from coded position 5 ('C').
- Position 4 receives the letter from coded position 2 ('N').
- Position 5 receives the letter from coded position 3 ('I').
- Position 6 remains 'C'.
- Assembling the letters yields: P - I - C - N - I - C, which spells the word **PICNIC**.

Why other options are incorrect:

- Option A:** PINCIC fails to swap letters at positions 3 and 5.
- Option B:** PNICIC leaves the second letter unswapped.
- Option D:** PICCIN misplaces the final consonants.

Question #199 Key: (B)LOGICAL REASONING
12. Linear Ranking, Ordering & Inequalities

Five bags are placed in a vertical pile one on top of the other. Bag [Formula] is above bag [Fo...

CORE CONCEPT & DERIVATION

Positional ordering problems are resolved by combining individual pairwise relative rank conditions into a single linear sequence.

Formula / Rule / Reaction:

Conditions: $A > B$, $E > C > D$, $D > A$

Solution:

- From the condition 'C is above D but below E': $E > C > D$.
- From the condition 'D is above A': $E > C > D > A$.
- From the condition 'A is above B': $E > C > D > A > B$.
- The complete top-to-bottom order of the five bags is:
- 1. E (Top)
- 2. C
- 3. D (Middle)
- 4. A
- 5. B (Bottom)
- Bag D occupies the third position, which is the exact middle of the five-bag pile.

Why other options are incorrect:

- Option A:** Bag E sits at the very top of the pile (position 1).
- Option C:** Bag A occupies the fourth position from the top.
- Option D:** Bag B is at the bottom of the pile (position 5).

Question #200 **Key: (D)**LOGICAL REASONING
08. Letter Series & Coding-Decoding

Find the term that does not fit into the established logical sequence: $1, 5, 9, 13, 17, 21, 25, 29, 33, 37, 41, 45, 49, 53, 57, 61, 65, 69, 73, 77, 81, 85, 89, 93, 97, 101, 105, 109, 113, 117, 121, 125, 129, 133, 137, 141, 145, 149, 153, 157, 161, 165, 169, 173, 177, 181, 185, 189, 193, 197, 201, 205, 209, 213, 217, 221, 225, 229, 233, 237, 241, 245, 249, 253, 257, 261, 265, 269, 273, 277, 281, 285, 289, 293, 297, 301, 305, 309, 313, 317, 321, 325, 329, 333, 337, 341, 345, 349, 353, 357, 361, 365, 369, 373, 377, 381, 385, 389, 393, 397, 401, 405, 409, 413, 417, 421, 425, 429, 433, 437, 441, 445, 449, 453, 457, 461, 465, 469, 473, 477, 481, 485, 489, 493, 497, 501, 505, 509, 513, 517, 521, 525, 529, 533, 537, 541, 545, 549, 553, 557, 561, 565, 569, 573, 577, 581, 585, 589, 593, 597, 601, 605, 609, 613, 617, 621, 625, 629, 633, 637, 641, 645, 649, 653, 657, 661, 665, 669, 673, 677, 681, 685, 689, 693, 697, 701, 705, 709, 713, 717, 721, 725, 729, 733, 737, 741, 745, 749, 753, 757, 761, 765, 769, 773, 777, 781, 785, 789, 793, 797, 801, 805, 809, 813, 817, 821, 825, 829, 833, 837, 841, 845, 849, 853, 857, 861, 865, 869, 873, 877, 881, 885, 889, 893, 897, 901, 905, 909, 913, 917, 921, 925, 929, 933, 937, 941, 945, 949, 953, 957, 961, 965, 969, 973, 977, 981, 985, 989, 993, 997, 1001, 1005, 1009, 1013, 1017, 1021, 1025, 1029, 1033, 1037, 1041, 1045, 1049, 1053, 1057, 1061, 1065, 1069, 1073, 1077, 1081, 1085, 1089, 1093, 1097, 1101, 1105, 1109, 1113, 1117, 1121, 1125, 1129, 1133, 1137, 1141, 1145, 1149, 1153, 1157, 1161, 1165, 1169, 1173, 1177, 1181, 1185, 1189, 1193, 1197, 1201, 1205, 1209, 1213, 1217, 1221, 1225, 1229, 1233, 1237, 1241, 1245, 1249, 1253, 1257, 1261, 1265, 1269, 1273, 1277, 1281, 1285, 1289, 1293, 1297, 1301, 1305, 1309, 1313, 1317, 1321, 1325, 1329, 1333, 1337, 1341, 1345, 1349, 1353, 1357, 1361, 1365, 1369, 1373, 1377, 1381, 1385, 1389, 1393, 1397, 1401, 1405, 1409, 1413, 1417, 1421, 1425, 1429, 1433, 1437, 1441, 1445, 1449, 1453, 1457, 1461, 1465, 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4125, 4129, 4133, 4137, 4141, 4145, 4149, 4153, 4157, 4161, 4165, 4169, 4173, 4177, 4181, 4185, 4189, 4193, 4197, 4201, 4205, 4209, 4213, 4217, 4221, 4225, 4229, 4233, 4237, 4241, 4245, 4249, 4253, 4257, 4261, 4265, 4269, 4273, 4277, 4281, 4285, 4289, 4293, 4297, 4301, 4305, 4309, 4313, 4317, 4321, 4325, 4329, 4333, 4337, 4341, 4345, 4349, 4353, 4357, 4361, 4365, 4369, 4373, 4377, 4381, 4385, 4389, 4393, 4397, 4401, 4405, 4409, 4413, 4417, 4421, 4425, 4429, 4433, 4437, 4441, 4445, 4449, 4453, 4457, 4461, 4465, 4469, 4473, 4477, 4481, 4485, 4489, 4493, 4497, 4501, 4505, 4509, 4513, 4517, 4521, 4525, 4529, 4533, 4537, 4541, 4545, 4549, 4553, 4557, 4561, 4565, 4569, 4573, 4577, 4581, 4585, 4589, 4593, 4597, 4601, 4605, 4609, 4613, 4617, 4621, 4625, 4629, 4633, 4637, 4641, 4645, 4649, 4653, 4657, 4661, 4665, 4669, 4673, 4677, 4681, 4685, 4689, 4693, 4697, 4701, 4705, 4709, 4713, 4717, 4721, 4725, 4729, 4733, 4737, 4741, 4745, 4749, 4753, 4757, 4761, 4765, 4769, 4773, 4777, 4781, 4785, 4789, 4793, 4797, 4801, 4805, 4809, 4813, 4817, 4821, 4825, 4829, 4833, 4837, 4841, 4845, 4849, 4853, 4857, 4861, 4865, 4869, 4873, 4877, 4881, 4885, 4889, 4893, 4897, 4901, 4905, 4909, 4913, 4917, 4921, 4925, 4929, 4933, 4937, 4941, 4945, 4949, 4953, 4957, 4961, 4965, 4969, 4973, 4977, 4981, 4985, 4989, 4993, 4997, 5001, 5005, 5009, 5013, 5017, 5021, 5025, 5029, 5033, 5037, 5041, 5045, 5049, 5053, 5057, 5061, 5065, 5069, 5073, 5077, 5081, 5085, 5089, 5093, 5097, 5101, 5105, 5109, 5113, 5117, 5121, 5125, 5129, 5133, 5137, 5141, 5145, 5149, 5153, 5157, 5161, 5165, 5169, 5173, 5177, 5181, 5185, 5189, 5193, 5197, 5201, 5205, 5209, 5213, 5217, 5221, 5225, 5229, 5233, 5237, 5241, 5245, 5249, 5253, 5257, 5261, 5265, 5269, 5273, 5277, 5281, 5285, 5289, 5293, 5297, 5301, 5305, 5309, 5313, 5317, 5321, 5325, 5329, 5333, 5337, 5341, 5345, 5349, 5353, 5357, 5361, 5365, 5369, 5373, 5377, 5381, 5385, 5389, 5393, 5397, 5401, 5405, 5409, 5413, 5417, 5421, 5425, 5429, 5433, 5437, 5441, 5445, 5449, 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