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BUMHS QUETTA

BUMHS Quetta MDCAT 2023 Official Paper

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

🛡️ Official Admitting Board: Bolan University of Medical and Health Sciences Quetta 🎯 Archive Code: BEAMBE-FLP-BUMHS-2023

🕒 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

The temperature at which an inactive enzyme regains its function is called:

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

Q2. BIO

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

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

Q3. BIO

Which of the following is a product of neurosecretory cells?

- (A) Aldosterone
- (B) Thyroxine
- (C) Corticosterone
- (D) Vasopressin

Q4. BIO

Lipoprotein particles make membranes containing various enzymes and F_1 particles in:

- (A) Crista
- (B) Cisternae
- (C) Forming face
- (D) Matrix

Q5. BIO

Which of the following viruses is classified as an ssDNA virus?

- (A) Diarrhea virus
- (B) Mild rash virus
- (C) Rubella virus
- (D) Smallpox virus

Q6. BIO

Catastrophism was explained by:

- (A) Wallace
- (B) Cuvier
- (C) Malthus
- (D) Darwin

Q7. BIO

Plasma membrane is:

- (A) Biradially Symmetrical
- (B) Asymmetrical
- (C) Radially Symmetrical
- (D) Bilaterally Symmetrical

Q8. BIO

How many valves are present in a human heart?

- (A) 2
- (B) 4
- (C) 3
- (D) 6

Q9. BIO

Among chemical substances found in living organisms, water, acids, bases, and salts are classified as:

- (A) Chemical
- (B) Inorganic
- (C) Physical
- (D) Organic

Q10. BIO

Casparian strips are present in:

- (A) Endodermis
- (B) Cortex
- (C) Pericycle
- (D) Epidermis

Q11. BIO

Which is the function associated with the Golgi apparatus?

- (A) Modification of proteins and lipids
- (B) Protein synthesis
- (C) Nerve impulse transmission
- (D) Detoxification of drugs

Q12. BIO

Cerebrospinal Fluid (CSF) is found between:

- (A) Pia and dura mater
- (B) Dura and arachnoid mater
- (C) Arachnoid and pia mater
- (D) Cranium and dura mater

Q13. BIO

The butterfly-shaped central part of the spinal cord is composed of a special structure known as:

- (A) Grey Matter
- (B) White Matter
- (C) Both Grey and White Matter
- (D) Neuroglial Protein

Q14. BIO

Which one is a chemotherapeutic agent to destroy and stop the growth of bacteria?

- (A) Phenol
- (B) Spirit
- (C) Penicillin
- (D) Sulphuric Acid

Q15. BIO

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

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

Q16. BIO

With reference to female reproduction, the exchange of which material is non-placental?

- (A) Wastes
- (B) Gases
- (C) Blood
- (D) Nutrients

Q17. BIO

The largest group in the animal kingdom is:

- (A) Arthropoda
- (B) Mammals
- (C) Mollusca
- (D) Nematodes

Q18. BIO

The different members of colonies in coelenterates that perform different functions are:

- (A) Workers
- (B) Drones
- (C) Zooplanktons
- (D) Zooids

Q19. BIO

Which of the following is incorrect about lungs?

- (A) Occupy intrathoracic cavity
- (B) Slightly unequal in size
- (C) Respiratory organ of all organisms
- (D) Encased in pleura

Q20. BIO

Which of the following is responsible for producing the 'LUB DUB' sound of the heart?

- (A) Closing of valves in the heart
- (B) Contraction of the atria
- (C) Contraction of muscles
- (D) Contraction of ventricles

Q21. BIO

What are capsomeres composed of?

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

Q22. BIO

After ovulation, the ruptured follicle is transformed into a glandular mass called:

- (A) Graafian follicle
- (B) Corpus allatum
- (C) Primary follicle
- (D) Corpus luteum

Q23. BIO

Tristearin is a/an:

- (A) Lipid
- (B) Protein
- (C) Enzyme
- (D) Amino Acid

Q24. BIO

What will be the F2 phenotypic ratio if a red-flowered male plant is bred with a white-flowered female plant, where red flower color is dominant over white flower color?

- (A) In a ratio of 1:2
- (B) In a ratio of 1:1
- (C) In a ratio of 3:1
- (D) In a ratio of 1:3

Q25. BIO

Upon hydrolysis, cellulose yields:

- (A) disaccharide called cellobiose
- (B) A trisaccharide called cellobiose
- (C) A monosaccharide called galactose
- (D) A disaccharide called maltose

Q26. BIO

HIV belongs to which group of viruses?

- (A) DNA virus
- (B) DNA enveloped virus
- (C) Protein tumor virus
- (D) Retrovirus

Q27. BIO

Which cell type does not have histones with DNA to make chromosomes?

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

Q28. BIO

Lactic acid accumulation in skeletal muscle cells causes:

- (A) Muscular atrophy
- (B) Muscle cramp
- (C) Muscle fatigue
- (D) Muscle tetany

Q29. BIO

In how many stages is the HIV infection process divided?

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

Q30. BIO

What is the color of Chlorophyll-a molecules?

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

Q31. BIO

The thick filament, which is 16nm in diameter, is composed of?

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

Q32. BIO

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

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

Q33. BIO

Which among the following permits interbreeding among individuals of the same species?

- (A) Reproductive isolation
- (B) Mutation
- (C) Chromosomal aberration
- (D) Common habitat

Q34. BIO

When do anti-A and anti-B antibodies appear in plasma?

- (A) During early development
- (B) During the first few months of life
- (C) At the age of puberty
- (D) When exposed to the wrong blood group

Q35. BIO

Which of the following is NOT an event of light-dependent reactions during photosynthesis?

- (A) Photolysis of water
- (B) Production of ATP by photophosphorylation
- (C) Reduction of Carbon dioxide
- (D) Reduction of NADP to NADPH

Q36. BIO

What are the living cells of cartilage called?

- (A) Astrocytes
- (B) Chondrocytes
- (C) Osteocytes
- (D) Melanocytes

Q37. BIO

In prokaryotic cells, which one of the following organelles is present?

- (A) Mitochondria
- (B) Nucleus
- (C) Golgi apparatus
- (D) Ribosomes

Q38. BIO

Phycocyanin is a pigment present in cyanobacteria.

Phycocyanin is of _____ color.

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

Q39. BIO

The flow of lymph is always towards _____?

- (A) Carotid arteries
- (B) Iliac arteries
- (C) Thoracic lymph duct
- (D) Thymus gland

Q40. BIO

Fossil of Cro-Magnon was collected from?

- (A) South America
- (B) Great Britain
- (C) Ireland
- (D) France

Q41. BIO

NAD is a:

- (A) Mononucleotide
- (B) Dinucleotide
- (C) Trinucleotide
- (D) Polynucleotide

Q42. BIO

Which of the following is a viral sexually transmitted disease?

- (A) Dengue
- (B) Genital Herpes
- (C) Gonorrhea
- (D) Syphilis

Q43. BIO

In prokaryotes, the function of mitochondria is performed by which one of the following?

- (A) Mesosome
- (B) Periplasm
- (C) Ribosome
- (D) Plasmid

Q44. BIO

Sterilization of blood products is carried out by?

- (A) Chemicals
- (B) Drying
- (C) Heat
- (D) Radiation

Q45. BIO

Which hormone controls the release of milk from the mammary glands?

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

Q46. BIO

Which of the following is a conjugated molecule?

- (A) Polysaccharides
- (B) Glycoproteins
- (C) Glycogen
- (D) Starch

Q47. BIO

Who discovered the ABO blood group system?

- (A) Bernstein
- (B) Mendel
- (C) Landsteiner
- (D) Levine

Q48. BIO

As water changes into vapor:

- (A) Its molecules move at a slower pace
- (B) It warms the surrounding environment
- (C) Its kinetic energy decreases
- (D) It cools the surrounding environment

Q49. BIO

What are nerve impulses?

- (A) Electromechanical Waves
- (B) Electromagnetic Waves
- (C) Electromechano Waves
- (D) Electrochemical Waves

Q50. BIO

Which one of the following is the direct source of energy in living bodies?

- (A) ATP
- (B) Glucose
- (C) Amino acid
- (D) Fatty acid

Q51. BIO

Epididymis opens into:

- (A) Vas deferens
- (B) Ejaculatory duct
- (C) Urinogenital duct
- (D) Vas efferens

Q52. BIO

The phenomenon responsible for genetic variation is:

- (A) Mitosis
- (B) Cloning
- (C) Gene linkage
- (D) Crossing over

Q53. BIO

The infundibulum connects the pituitary gland to the:

- (A) Cerebellum
- (B) Cerebrum
- (C) Hypothalamus
- (D) Thalamus

Q54. BIO

Both enzymes and coenzymes are:

- (A) Inorganic
- (B) Reused
- (C) Derived from vitamins
- (D) Globular proteins

Q55. BIO

Trans face of the Golgi complex is a:

- (A) Forming face that consists of young cisternae
- (B) Forming face that consists of old cisternae
- (C) Maturing face that consists of newly built cisternae
- (D) Maturing face that consists of old cisternae

Q56. BIO

Which type of organisms first evolved about 1.5 billion years ago?

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

Q57. BIO

Which of the following statement is NOT true about proteins?

- (A) Proteins are nitrogenous compounds
- (B) Proteins are building blocks of tissues
- (C) Proteins are hydrated carbons
- (D) Proteins are polymers of amino acids

Q58. BIO

Trace amounts of vitamins function in the body primarily as:

- (A) Structural components
- (B) Hormones
- (C) Coenzymes
- (D) Energy sources

Q59. BIO

Cyanides block the action of enzymes by combining with:

- (A) Prosthetic group
- (B) Coenzyme
- (C) Cofactor
- (D) Activator

Q60. BIO

Action potential in the neuronal membrane starts the process of?

- (A) Polarization
- (B) Depolarization
- (C) Repolarization
- (D) Hyperpolarization

Q61. BIO

The maximum water potential of pure water is:

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

Q62. BIO

Fasciola, an endoparasite in sheep, is mostly found in:

- (A) Blood of sheep
- (B) Large intestine of sheep
- (C) Liver and bile duct of sheep
- (D) Stomach of sheep

Q63. BIO

In chlorophyll a, a $-\text{CH}_3$ group is attached to which pyrrole ring?

- (A) 1st
- (B) 2nd
- (C) 3rd
- (D) 4th

Q64. BIO

Which of the following organelles contains circular DNA and small-sized ribosomes?

- (A) Nucleus
- (B) Mitochondria
- (C) Golgi complex
- (D) Endoplasmic reticulum

Q65. BIO

Which of the following transport processes require energy for the movement of material across the plasma membrane?

- (A) Osmosis
- (B) Diffusion
- (C) Endocytosis
- (D) Facilitated diffusion

Q66. BIO

The mode of inheritance in humans can be traced through:

- (A) Experimental Mating
- (B) Chi-Square Chart
- (C) Pedigree Analysis
- (D) Probability Analysis

Q67. BIO

Animals having jointed legs and a chitinous exoskeleton are known as:

- (A) Chordates
- (B) Arthropods
- (C) Annelida
- (D) Mollusca

Q68. BIO

Passage of water across a selectively permeable membrane is called:

- (A) Active transport
- (B) Osmosis
- (C) Pinocytosis
- (D) Facilitated diffusion

CHEM SECTION: CHEMISTRY

Questions 69 to 122 (54 MCQs)

Q69. CHEM

The system in which three angles and axes are unequal is called?

- (A) Cubic system
- (B) Triclinic system
- (C) Orthorhombic system
- (D) Trigonal system

Q70. CHEM

Which one is incorrect for actual yield being less than theoretical yield?

- (A) Mechanical losses
- (B) Reversibility of reaction
- (C) All molecules do not possess activation energy
- (D) Substance is pure

Q71. CHEM

Which of the following is the carbon atom of a carbonyl group?

- (A) sp hybridized
- (B) sp^2 hybridized
- (C) sp^3 hybridized
- (D) dsp^2 hybridized

Q72. CHEM

The acylium ion has a positive charge and acts as:

- (A) Nucleophile
- (B) Electrophile
- (C) Carbocation
- (D) Carbanion

Q73. CHEM

Why is the first ionization energy of Beryllium higher than Boron?

- (A) Boron has a higher electronic configuration than Beryllium
- (B) Atomic radius of Beryllium is smaller than Boron
- (C) Beryllium has a stable electronic configuration
- (D) Boron has a smaller atomic number than Beryllium

Q74. CHEM

Which one of the following has no cleavage plane?

- (A) Graphite
- (B) NaCl crystals
- (C) Copper crystals
- (D) Ice

Q75. CHEM

Which of the following metals does not react with water?

- (A) Mg
- (B) Ca
- (C) Na
- (D) Be

Q76. CHEM

A set of postulates that explain the behavior of an ideal gas is called:

- (A) Bohr theory
- (B) Kinetic molecular theory of gases
- (C) Rutherford theory
- (D) Dalton's theory

Q77. CHEM

The general electronic configuration of halide ions is:

- (A) ns^2np^5
- (B) ns^2np^6
- (C) ns^1np^5
- (D) ns^2np^3

Q78. CHEM

Thermodynamically, the most stable form of carbon is:

- (A) Diamond
- (B) Graphite
- (C) Peat
- (D) Coal

Q79. CHEM

Protein content of human milk is about

- (A) 1.4%
- (B) 2.4%
- (C) 3.4%
- (D) 4.4%

Q80. CHEM

In base-catalyzed nucleophilic addition reactions of aldehydes and ketones, the base reagent acts to generate a strong:

- (A) Amphoteric
- (B) Nucleophile
- (C) Electrophobic
- (D) Electrophilic

Q81. CHEM

Which of the following is a bidentate ligand?

- (A) Ammine
- (B) Hydrazine
- (C) Aqua
- (D) Carbonyl

Q82. CHEM

What do we mean by the term "delocalized electrons" in benzene?

- (A) Electrons that are free to move around the molecule in the π bonding system above and below the plane of the carbon atoms in the benzene ring
- (B) Electrons that are not free to move around the molecule in the π bonding system above and below the plane of the carbon atoms in the benzene ring
- (C) Electrons that are free to move around the molecule in the σ bonding system above and below the plane of the carbon atoms in the benzene ring
- (D) Electrons that are free to move around the molecule in the π bonding in the benzene ring

Q83. CHEM

Which of the following pairs is isostructural?

- (A) AlCl_3 and CH_4
- (B) BF_3 and NH_3
- (C) SnCl_2 and BeCl_2
- (D) SO_3 and BF_3

Q84. CHEM

Acetic acid is a weaker acid than sulfuric acid because of which of the following reasons?

- (A) It decomposes on increasing temperature
- (B) It has a lesser degree of ionization
- (C) It has a $-\text{COOH}$ group
- (D) It has more inductive effect

Q85. CHEM

Number of primary carbon atoms present in isobutane

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

Q86. CHEM

In which method can the rate of reaction involving ions be studied

- (A) Electrical conductivity method
- (B) Optical rotation method
- (C) Refractometric method
- (D) Spectrometry

Q87. CHEM

What occurs when carbonyl compounds react with HCN

- (A) The reaction is catalyzed by concentrated H_2SO_4
- (B) Pentan-2-one and HCN react to give a chiral product
- (C) The reaction is a condensation reaction
- (D) The reaction is nucleophilic substitution

Q88. CHEM

The overall charge on the transition state in an $\text{S}_\text{N}2$ reaction is?

- (A) Negative
- (B) Positive
- (C) Neutral
- (D) Partially negative

Q89. CHEM

Which ionic radius is the smallest?

- (A) Na^+
- (B) Mg^{2+}
- (C) Al^{3+}
- (D) Mg^+

Q90. CHEM

What is the quantum number for the unpaired electron of a chlorine atom (n, l, m)?

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

Q91. CHEM

Group IB is called the coinage metals. Which one is not true about this group?

- (A) Have powerful reducing agents
- (B) Have positive reduction potential
- (C) Cannot displace H_2 from dilute acids
- (D) Lies below SHE in electrochemical series

Q92. CHEM

What is the weight of oxygen that required for the complete combustion of 3.2 kg of methane?

- (A) 3.2 kg
- (B) 6.4 kg
- (C) 12.8 kg
- (D) 15.4 kg

Q93. CHEM

How many moles of a gas occupy 30.57 L at 55°C and 0.83 atm?

- (A) 0.1 mol
- (B) 0.62 mol
- (C) 0.84 mol
- (D) 0.94 mol

Q94. CHEM

Which statement about a 4d orbital is correct?

- (A) It is at a higher energy level than a 4p orbital but has the same shape
- (B) It is occupied by one electron in an isolated Zn atom
- (C) It can hold a maximum of 10 electrons
- (D) It has the highest energy of the orbitals with principal quantum number 4

Q95. CHEM

Hess's law states the same thing as

- (A) Henry's law
- (B) Second law of thermodynamics
- (C) First law of thermodynamics
- (D) Second law of thermochemistry

Q96. CHEM

Which of the following is not true about canal rays?

- (A) 1.6726×10^{-27} kg
- (B) 9.54×10^7 C/kg
- (C) Show deflection under electric & magnetic fields
- (D) Do not cause mechanical motion

Q97. CHEM

The solubility of carboxylic acid in water gradually decreases with:

- (A) Decreases in molecular mass
- (B) Increases in molecular mass
- (C) Increases the amount of acid
- (D) Decreases the amount of water

Q98. CHEM

The polar part of soap and detergent dissolves in water molecules due to:

- (A) Dipole-dipole forces
- (B) Dipole-induced dipole forces
- (C) Hydrogen bonding
- (D) London dispersion forces

Q99. CHEM

When equal moles of reactants A and B are allowed to react according to the following balanced equation. ($2A + B \rightarrow \text{Product}$). The limiting reactant in this chemical equation will be?

- (A) Reactant A
- (B) Reactant B
- (C) Reactant A and B
- (D) No Limiting reactant:

Q100. CHEM

The hydrocarbon which has three linear fused benzene rings?

- (A) Phenanthrene
- (B) Triphenylmethane
- (C) Diphenyl ether
- (D) Anthracene

Q101. CHEM

Which functional group is characteristic of an ester?

- (A) R-CO-R
- (B) R-CO-OR
- (C) R-CO-OH
- (D) R-O-R

Q102. CHEM

Which of the following acids has the smallest dissociation constant?

- (A) $\text{CH}_3\text{CHF}\text{COOH}$
- (B) $\text{FCH}_2\text{CH}_2\text{COOH}$
- (C) $\text{BrCH}_2\text{CH}_2\text{COOH}$
- (D) $\text{CH}_3\text{CHBrCOOH}$

Q103. CHEM

At atmospheric pressure, glycerin boils with decomposition at 290°C . What is the boiling point of glycerin under vacuum distillation at 50 torr?

- (A) 320°C
- (B) 310°C
- (C) 300°C
- (D) 210°C

Q104. CHEM

The solubility of KClO_3 is decreased by adding:

- (A) KCl
- (B) KClO_3
- (C) H_2O
- (D) Not affected

Q105. CHEM

For every reaction occurring in the human body, there is at least one type of:

- (A) Vitamins
- (B) Enzymes
- (C) Proteins
- (D) Amino acids

Q106. CHEM

Why do transition elements form alloys so easily?

- (A) Atomic size
- (B) Orbital configuration
- (C) Very light
- (D) Hard elements

Q107. CHEM

Methanol is prepared from carbon monoxide and hydrogen. The catalyst used for this reaction is:

- (A) $\text{ZnO} + \text{CoO}_2$
- (B) $\text{ZnO} + \text{CuO}$
- (C) $\text{ZnO} + \text{Ag}_2\text{O}$
- (D) $\text{Cr}_2\text{O}_3 + \text{ZnO}$

Q108. CHEM

Which of the following statements is true about Grignard reagent (RMgX)?

- (A) RMgX is prepared in an aqueous medium
- (B) RMgX is prepared in ether
- (C) RMgX does not react with water
- (D) RMgX is inactive in ethanol

Q109. CHEM

Air at sea level is dense. This is a practical application of:

- (A) Boyle's law
- (B) Charles's law
- (C) Avogadro's law
- (D) Dalton's law

Q110. CHEM

Which of the following acids can show cis-trans isomerism?

- (A) Malonic acid
- (B) Maleic acid
- (C) Succinic acid
- (D) Lactic acid

Q111. CHEM

What is the reactivity state of Phenols?

- (A) Less reactive
- (B) More reactive
- (C) Neutral
- (D) Non reactive

Q112. CHEM

Why do electrons have opposite spins when they are in the same orbital?

- (A) This condition reduces friction
- (B) This condition creates more energy
- (C) This condition results in zero magnetism and removes the charge of the electron
- (D) This condition results in less repulsion and opposite magnetic fields

Q113. CHEM

Which of the following is not an endothermic reaction?

- (A) Combustion of methane
- (B) Decomposition of water
- (C) Dehydrogenation of ethane or ethylene
- (D) Conversion of graphite

Q114. CHEM

Which order of reaction obeys the expression $t_{1/2} = 1/k_a$?

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

Q115. CHEM

What is the common name of 1,2,3-propanetriol?

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

Q116. CHEM

When an aqueous solution of NaCl is electrolyzed:

- (A) Cl_2 is evolved at the cathode
- (B) H_2 is evolved at the cathode
- (C) Na is deposited at the cathode
- (D) Na appears at the anode

Q117. CHEM

The equilibrium stage that is not affected by temperature is called:

- (A) Static equilibrium
- (B) Natural equilibrium
- (C) Dynamic equilibrium
- (D) Unstable equilibrium

Q118. CHEM

Which of the following carbon atoms is sp^2 hybridized?

- (A) Cyclopropane
- (B) Diamond
- (C) Graphite
- (D) Hexane

Q119. CHEM

Sp^2 hybrid carbon atom is present in

- (A) Methanal
- (B) Methanol
- (C) Ethanol
- (D) 2-Propanol

Q120. CHEM

What is the fact due to which branching decreases boiling point?

- (A) As branching increases, the attractive forces between molecules increase
- (B) As branching increases, it decreases attractive forces
- (C) As branching increases, it increases surface area for making attractive forces
- (D) As branching increases, it decreases the surface area for attractive forces

Q121. CHEM

Temperature increase in an exothermic reversible reaction shifts the equilibrium to

- (A) Product side
- (B) Reactant side
- (C) Remains unchanged
- (D) Increase in both

Q122. CHEM

Which product is formed when RMgX reacts with CO_2 ?

- (A) Aldehydes
- (B) Ketones
- (C) Carboxylic acid
- (D) Ethers

PHY SECTION: PHYSICS

Questions 123 to 176 (54 MCQs)

Q123. PHY

The minimum gradient of a curve on a displacement–time graph of a ball thrown vertically upwards and caught back can be:

- (A) Zero
- (B) 9.81
- (C) 90 degrees
- (D) Equal to the final velocity of the motion

Q124. PHY

Coulomb's law is only true for point charges whose sizes are:

- (A) Medium
- (B) Very large
- (C) Very small
- (D) Large

Q125. PHY

The magnetic field depends upon:

- (A) Strength, mass, and nature of magnetic materials
- (B) Strength, mass, and direction
- (C) Strength, distance, and direction
- (D) Strength, nature of magnetic materials, and distance

Q126. PHY

When a gas is compressed isothermally, the product of its pressure and volume during the process is:

- (A) Not constant
- (B) Constant
- (C) Proportional to temperature
- (D) Proportional to entropy

Q127. PHY

Which one of the following bulbs has the least resistance, if the current is kept constant?

- (A) 100 watt
- (B) 200 watt
- (C) 300 watt
- (D) 400 watt

Q128. PHY

A coil of area 1 m^2 has 100 turns. It rotates with constant angular velocity about an axis along its diameter perpendicular to Earth's magnetic field of $B = 1 \times 10^{-5} \text{ T}$. The angular velocity for induced emf of 1 mV is?

- (A) Zero
- (B) 1 rad/s
- (C) 7.96 rad/s
- (D) 10 rad/s

Q129. PHY

When a transverse wave passes, the particles of the medium oscillate:

- (A) With different harmonics
- (B) With different frequencies
- (C) Parallel to the direction of wave travel
- (D) Perpendicular to the direction of wave travel

Q130. PHY

A capacitor is charged with a battery, storing energy U . An identical capacitor is connected in parallel to the first one. The energy stored in each capacitor is:

- (A) U
- (B) $U/2$
- (C) $4U$
- (D) $2U$

Q131. PHY

If the value of acceleration due to gravity ' g ' is reduced to half, the time of flight T of projectile becomes:

- (A) $T/2$
- (B) $T/4$
- (C) $2T$
- (D) $4T$

Q132. PHY

Which of the following has the largest energy?

- (A) photon of wavelength 1 nm
- (B) A photon of wavelength $50 \mu\text{m}$
- (C) A photon of wavelength 2 pm
- (D) A photon of wavelength 200 nm

Q133. PHY

How much energy is converted in a resistor of 5 ohm carrying a current of 2.0 A after 10 seconds?

- (A) 4.0 J
- (B) 25 J
- (C) 100 J
- (D) 200 J

Q134. PHY

The longest wavelength of Lyman series is equal to?

- (A) $1/R_H$
- (B) $9/R_H$
- (C) $4/3 R_H$
- (D) $4/2 R_H$

Q135. PHY

What is the SI unit of conductivity?

- (A) Ohm–1m
- (B) mho m–1
- (C) siemen
- (D) mho–1m–2

Q136. PHY

The angle subtended at the center of a circle by an arc equal to $1/60$ th of a degree is called:

- (A) One minute
- (B) One radian
- (C) One second
- (D) One steradian

Q137. PHY

The magnetic flux through an area A in a uniform magnetic field B is given as:

- (A) $B \cdot A$
- (B) $BA \sin \theta$
- (C) $BA \cos 2\theta$
- (D) $BA \tan \theta$

Q138. PHY

High-frequency vibration is of:

- (A) 10 kHz
- (B) 0.1 MHz
- (C) 1 kHz
- (D) 1000 Hz

Q139. PHY

Electric field lines are:

- (A) Actual lines
- (B) Imaginary lines
- (C) Solid lines
- (D) Always curve lines

Q140. PHY

In British Engineering system, 1 Horse Power

- (A) 550 ft Pound/sec
- (B) 746 ft Pound/sec
- (C) 550 watt
- (D) 550 kilowatt hour

Q141. PHY

Two point charges, each of magnitude q , are separated by a distance $2d$. At a point mid-way between:

- (A) $E=0, V=0$
- (B) $E \neq 0, V=0$
- (C) $E=0, V \neq 0$
- (D) $E \neq 0, V \neq 0$

Q142. PHY

A low energy neutron has RBE factor of 10. How much energy is absorbed by a man of mass 80 Kg. if the value of equivalent dose is 400 rem?

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

Q143. PHY

A circuit that converts pulsating voltage of the rectifier to smooth voltage is known as:

- (A) Generator
- (B) Transformer
- (C) Filter
- (D) Choke

Q144. PHY

An object of mass ' m ' moving with speed ' v ' has a head-on wave collision with another object of mass $4m$ moving with speed ' v ' in the opposite direction. The objects stick together after the collision. What is the total loss of the kinetic energy

- (A) $(1/2)mv^2$
- (B) $2mv^2$
- (C) $(1/10)mv^2$
- (D) $(18/5)mv^2$

Q145. PHY

If C_v denotes molar specific heat at constant volume and ΔT is the change in temperature, then $C_v \Delta T$ gives:

- (A) Volume
- (B) Pressure
- (C) Entropy
- (D) Internal energy

Q146. PHY

If the initial velocity ' u ' of the projectile is doubled, height ' H ' of the projectile becomes:

- (A) $H/2$
- (B) $H/4$
- (C) $2H$
- (D) $4H$

Q147. PHY

A step down transformer is used to light a 12 volt 24 mA lamp from the 240 mains the current through primary is 1.5 mA. What is the efficiency of the transformer?

- (A) 60%
- (B) 70%
- (C) 90%
- (D) 80%

Q148. PHY

An oscillator performing simple harmonic motion has a displacement given by the $x = 8.0(\text{mm})\sin(10\pi/3)t$. What is the displacement when $t = 0.05\text{s}$?

- (A) $4\sqrt{2}\text{ mm}$
- (B) $4\sqrt{3}\text{ mm}$
- (C) 8 mm
- (D) 4 mm

Q149. PHY

According to the wave-particle duality, identify respectively how all micro-particles (electrons, protons, atoms, etc) behave when propagating and when exchanging energies

- (A) Waves, particles
- (B) Particles, waves
- (C) Particles, particles
- (D) Waves, waves

Q150. PHY

A solenoid of length 10 cm has magnetic flux density $B=0.50T$. When there is free space inside its turns. When the same solenoid is wound on iron core then its flux density is increased by

- (A) 14 times
- (B) 7 times
- (C) Remains Same
- (D) 140 times

Q151. PHY

Angular displacement is a vector quantity only when the?

- (A) Time of a circular motion is large enough
- (B) Time of circular motion has no effect
- (C) Time of circular motion is moderate
- (D) Time of circular motion is small enough

Q152. PHY

Volt can also be written as?

- (A) JC-2
- (B) JC
- (C) CN-1
- (D) JC-1

Q153. PHY

A low voltage supply with an e.m.f. of 20 V and an internal resistance of 1.5 ohms is used to supply power to a heater of resistance 6.5 ohms in a fish tank. What is the power supplied to the water in the fish tank?

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

Q154. PHY

When a nucleus emits beta particle, its mass number remains constant but charge number increases by:

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

Q155. PHY

The direction of centripetal acceleration in a circle?

- (A) Opposite to the centripetal force
- (B) Tangent to the circle
- (C) Parallel to the circle
- (D) Parallel to the centripetal force

Q156. PHY

The time constant of an RC circuit during discharge is that time in which charge on plates, as compared to maximum charge

- (A) 25 percent
- (B) 50 percent
- (C) 63.3 percent
- (D) 36.8 percent

Q157. PHY

Doppler effect can be observed by:

- (A) Longitudinal waves
- (B) Electromagnetic waves
- (C) Sound only
- (D) Both longitudinal and electromagnetic waves

Q158. PHY

The induced emf in a coil is 1 V. What will be the rate of change of area of that coil placed in a constant magnetic field of strength 0.1T ?

- (A) $0.1 \text{ m}^2\text{s}^{-1}$
- (B) $0.01 \text{ m}^2\text{s}^{-1}$
- (C) $1 \text{ m}^2\text{s}^{-1}$
- (D) $10 \text{ m}^2\text{s}^{-1}$

Q159. PHY

Work done on a rod moving in a magnetic field across magnetic field and generate an emf in the system. This statement is according to lenzs law of conservation of?

- (A) Mass
- (B) Momentum
- (C) Density
- (D) Energy

Q160. PHY

De Broglie received the Nobel Prize in the year:

- (A) 1905
- (B) 1927
- (C) 1929
- (D) 1937

Q161. PHY

Time of flight of a projectile depends upon

- (A) Launch angle only
- (B) Launch speed only
- (C) Launch speed and its angle
- (D) Launch height only

Q162. PHY

Which of the following is NOT CORRECT about potentiometer?

- (A) It measures the emf of a cell very accurately
- (B) Its sensitivity is low
- (C) It is based on the null deflection method
- (D) Its sensitivity is high

Q163. PHY

Work done in raising a box depends on

- (A) How fast it is raised
- (B) The strength of the person raising the box
- (C) The height it is raised to
- (D) The weight of the box and the height it is raised to

Q164. PHY

In earth's gravitational field, the absolute potential at any point in space is:

- (A) $(G M_e)/2R_e$
- (B) $(G m M_e)/R_e A^2$
- (C) $(G M_e)/R_e$
- (D) $(G m M_e)/R_e$

Q165. PHY

What physical quantity would result from a calculation in which a potential difference is multiplied by an electric charge

- (A) Electric current
- (B) Electric energy
- (C) Electric field strength
- (D) Electric power

Q166. PHY

Kinetic energy is the product of two vectors. It is:

- (A) Dot product of velocities
- (B) Cross product of velocities
- (C) Product of mass and velocity
- (D) Half product of mass and velocity squared

Q167. PHY

Which one is a variable capacitor

- (A) Ceramic capacitor
- (B) Air gap capacitor
- (C) Variable electrolytic capacitor
- (D) Silver capacitor

Q168. PHY

The velocity of sound in air is independent of:

- (A) Temperature
- (B) Pressure
- (C) Density
- (D) Humidity

Q169. PHY

The process of converting AC into DC is called:

- (A) Amplification
- (B) Rectification
- (C) Modulation
- (D) Detection

Q170. PHY

The force acting on a body of mass 10 kg is 100 N. The distance covered by the body in 10 seconds, if it starts from rest, is:

- (A) 100 m
- (B) 500 m
- (C) 1000 m
- (D) 5000 m

Q171. PHY

The rest mass of photon is:

- (A) One
- (B) Infinite
- (C) Zero
- (D) Depends on frequency

Q172. PHY

The velocity of sound in air at NTP is 332 ms^{-1} . The velocity of sound in vacuum is:

- (A) 332 ms^{-1}
- (B) 166 ms^{-1}
- (C) 88 ms^{-1}
- (D) Not defined

Q173. PHY

The electric field at a point situated at a distance d from a straight charged conductor is:

- (A) Proportional to d
- (B) Inversely proportional to d^2
- (C) Independent of d
- (D) Inversely proportional to d

Q174. PHY

The number of turns in the primary and secondary coils of a transformer are 10 and 2000 respectively. If the current in the primary is 1.0 A, What would be the current in the secondary

- (A) 0.05 A
- (B) 0.5 A
- (C) 5.0 A
- (D) 0.005 A

Q175. PHY

The energy of each photon with frequency $1.2 \times 10^{14} \text{ Hz}$ will be:

- (A) $7.9 \times 10^{-48} \text{ J}$
- (B) $7.9 \times 10^{-40} \text{ J}$
- (C) $7.9 \times 10^{-28} \text{ J}$
- (D) $7.9 \times 10^{-19} \text{ J}$

Q176. PHY

The magnitude of the vector product of two vectors is $\sqrt{3}$ times the scalar product. The angle between the two vectors is:

- (A) 45°
- (B) 90°
- (C) 30°
- (D) 60°

ENG SECTION: ENGLISH

Questions 177 to 194 (18 MCQs)

Q177. ENG

Choose the correct sentence:

- (A) Work all day, my father doesn't have much time to spare.
- (B) Working all day, my father don't have much time to spend.
- (C) Working all day, my father doesn't have much time to spend.
- (D) Working all day, my father doesn't have much time to spent.

Q178. ENG

Neither she nor _____ am guilty. Complete the sentence with the correct pronoun.

- (A) Us
- (B) We
- (C) They
- (D) Me

Q179. ENG

Choose the sentence that follows the correct adjectives order.

- (A) A beautiful blue sailing boat.
- (B) A blue beautiful sailing boat.
- (C) A beautiful sailing blue boat.
- (D) A blue sailing beautiful boat.

Q180. ENG

Use an appropriate article: He is extremely alert and watchful like _____ cat.

- (A) A
- (B) An
- (C) The
- (D) No article required

Q181. ENG

"I will not tolerate his rudeness." Choose the sentence that has the same meaning as the above sentence.

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

Q182. ENG

The boys on the opposite side made me _____ the bird.

- (A) To kill
- (B) Kills
- (C) Kill
- (D) Killed

Q183. ENG

Choose the sentence with correct semicolon placement.

- (A) The pen was expensive, still I bought it.
- (B) The pen was expensive still; I bought it.
- (C) The pen was expensive still I bought it.
- (D) The pen was expensive; still I bought it.

Q184. ENG

Choose a synonym for the underlined word:

Vicissitudes of life are unexpected; nothing remains the same.

- (A) Changes
- (B) Evils
- (C) Mistakes
- (D) Rules

Q185. ENG

You will have to catch the morning flight, so you _____ better get ready.

- (A) would
- (B) may
- (C) should
- (D) had

Q186. ENG

The most appropriate antonym for "abridge" is:

- (A) Condense
- (B) Lengthen
- (C) Shorten
- (D) Reduce

Q187. ENG

Which of the following is correct?

- (A) Forty years seems a long time.
- (B) Forty years seem long time.
- (C) Forty years seems long time.
- (D) Forty years seem a long time.

Q188. ENG

A boy is waiting for you for a long time. In this sentence, the word 'boy' is?

- (A) Proper Noun
- (B) Common Noun
- (C) Abstract Noun
- (D) Collective Noun

Q189. ENG

I _____ from college by this time next year and will be looking for a job.

- (A) Will graduate
- (B) Graduated
- (C) Will be graduating
- (D) Will have graduated

Q190. ENG

The most appropriate word to be filled in is: The melody is _____.

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

Q191. ENG

Which part of the sentence carries an error?

There were (A) five active workers (B) and three lazy one (D) in the factory (C).

- (A) There were
- (B) Five active workers
- (C) In the factory
- (D) And three lazy one

Q192. ENG

Choose the correct option to complete the given analogy: A lion is to a pride as a goose is to a ____ .

- (A) Feather
- (B) Flock
- (C) Gander
- (D) Pot

Q193. ENG

Fill in the blank with the correct word: Neither the invaders who were invading _____ happening.

- (A) Or
- (B) Nor
- (C) Not
- (D) None

Q194. ENG

Choose the sentence with an appropriately structured phrase:

- (A) They got married on a dull, sunny day in June.
- (B) They got married on a cloudy, sunny day in June.
- (C) They got married on a bright, sunny day in June.
- (D) They got married on a damp, sunny day in June.

LOGIC SECTION: LOGICAL REASONING

Questions 195 to 200 (6 MCQs)

Q195. LOGIC

Analyze the cause-and-effect relationship between the statements: I. The glaciers at the poles of the earth are melting at a fast rate. II. In recent times, there has been a substantial increase in the intensity of sunlight and volcanic eruptions.

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

Q196. LOGIC

Read the following statement, assuming everything in the statement to be true. Then decide which of the given suggested courses of action logically follows beyond a worth pursuing. Statement: An invigilator catches a student peeking at another student's worksheet in a school exam. Courses of Action: I. Immediately cancel both of the students' exams and remove them from the school. II. Change the student's position to one which is more secluded and give them a warning.

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

Q197. LOGIC

Observe the pattern and select the next term in the series. TEAM, TAME, TMEA,

- (A) MUET
- (B) TEAM
- (C) TAUM
- (D) MEAT

Q198. LOGIC

All children are silly people. Some silly people are rich people. All rich people are big shots. Which of the following conclusions are NECESSARILY TRUE? CONCLUSIONS: I. Some silly people are children. II. Some rich people are children. III. Some silly people are big shots.

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

Q199. LOGIC

X, Y and Z are three whole numbers less than 31 but greater than 23. X is a prime number. Y is the largest odd number smaller than 31. Z is the smallest even number?

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

Q200. LOGIC

Five cities P, Q, R, S and T are connected by different modes of transport as follows: P and Q are connected by boat as well as by rail; S and R are connected by bus and by boat; Q and T are connected only by air; P and R are connected only by boat; T and R are connected by rail and by bus. Which mode of transport would help one to reach R starting from Q but without changing mode of transport?

- (A) Boat
- (B) Rail
- (C) Bus
- (D) Air

OFFICIAL VERIFIED ANSWER KEY

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

SUBJECT-WISE PERFORMANCE BREAKDOWN

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

PMDC PROVINCIAL MERIT FORMULA

Official Weightage Law:

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

BIOLOGY
03. Enzymes

The temperature at which an inactive enzyme regains its function is called:

CORE CONCEPT & DERIVATION

Enzymes become reversibly inactivated at low temperatures due to reduced kinetic energy. The lowest temperature at which an inactive enzyme begins to regain catalytic activity upon warming is termed its minimum temperature.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- At temperatures below the minimum threshold, molecular motion decreases and enzymes are rendered inactive without undergoing denaturation.
- When the temperature is elevated to the minimum temperature, the enzyme regains the kinetic motion necessary to bind substrates and catalyze reactions. (Note: Although some unofficial keys marked optimum temperature, textbook definitions state that optimum temperature is the point of maximum reaction velocity, whereas the reactivation threshold is the minimum temperature).

Why other options are incorrect:

- Option A:** Maximum temperature is the highest temperature at which an enzyme can function before irreversible denaturation occurs.
- Option C:** Favourable temperature is a non-standard descriptive phrase rather than a recognized enzymological threshold.
- Option D:** Optimum temperature represents the temperature at which catalytic rate reaches its peak, not the threshold of reactivation from cold-induced dormancy.

Question #2 Key: (C)

BIOLOGY
15. Inheritance / Variation & Genetics

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

CORE CONCEPT & DERIVATION

Alleles are alternate forms of the same gene that occupy identical positions (loci) on homologous chromosomes.

Formula / Rule / Reaction:

Factual recall / Mendelian genetics.

Solution:

- Homologous chromosomes carry matching gene loci at corresponding positions.
- Dominance describes the phenotypic expression of one allele over its partner when both are present at the same locus on homologous chromosomes.

Why other options are incorrect:

- Option A:** Partner alleles do not reside on the same single chromosome; they reside on paired homologous chromosomes.
- Option B:** Non-allelic interactions occur at different loci, representing epistasis rather than allelic dominance.
- Option D:** Alleles must occupy corresponding (identical) loci on homologous chromosomes to display dominance relationships.

Question #3 Key: (D)

BIOLOGY
13. Chemical Coordination

Which of the following is a product of neurosecretory cells?

CORE CONCEPT & DERIVATION

Neurosecretory cells are specialized neurons that synthesize neurohormones and discharge them directly into the bloodstream.

Formula / Rule / Reaction:

Factual recall / Endocrine physiology.

Solution:

- Vasopressin (antidiuretic hormone, ADH) and oxytocin are synthesized by the supraoptic and paraventricular nuclei of the hypothalamus.
- These neurosecretory cells transport the peptide hormones down axons through the infundibulum to the posterior pituitary for storage and systemic release.

Why other options are incorrect:

- Option A:** Aldosterone is a mineralocorticoid synthesized by the zona glomerulosa cells of the adrenal cortex.
- Option B:** Thyroxine is an iodinated amino acid derivative secreted by the follicular cells of the thyroid gland.
- Option C:** Corticosterone is a steroid hormone synthesized by the adrenal cortex.

Question #4 Key: (A)

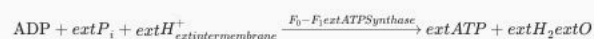
BIOLOGY
01. Cell

Lipoprotein particles make membranes containing various enzymes and [Formula] particles in:

CORE CONCEPT & DERIVATION

The inner mitochondrial membrane is extensively folded into cristae to accommodate electron transport chain complexes and ATP synthase complexes.

Formula / Rule / Reaction:



Solution:

- The inner mitochondrial membrane forms infoldings called cristae.
- These lipoprotein folds house electron carriers, respiratory dehydrogenases, and stalked elementary particles containing the catalytic F_1 headpiece of ATP synthase.

Why other options are incorrect:

- Option B:** Cisternae are flattened, membrane-bound sacs characteristic of the endoplasmic reticulum and Golgi apparatus.
- Option C:** The forming face (cis face) belongs to the Golgi apparatus and receives transport vesicles from the endoplasmic reticulum.
- Option D:** The mitochondrial matrix is the fluid interior containing Krebs cycle enzymes, ribosomes, and circular DNA, but lacks F_1 membrane particles.

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

Which of the following viruses is classified as an ssDNA virus?

CORE CONCEPT & DERIVATION

Parvoviruses are small, non-enveloped viruses that possess a single-stranded DNA genome.

Formula / Rule / Reaction:

Baltimore Classification: Group II (ssDNA viruses).

Solution:

- Parvovirus B19 causes fifth disease (erythema infectiosum), commonly known as mild rash of childhood or slapped-cheek syndrome.
- Parvoviruses are notable for possessing a linear single-stranded DNA genome.

Why other options are incorrect:

- **Option A:** Rotavirus, a common cause of severe viral diarrhea, has a double-stranded RNA (dsRNA) genome.
- **Option C:** Rubella virus is a member of the Togaviridae family and possesses a positive-sense single-stranded RNA (+ssRNA) genome.
- **Option D:** Variola virus (smallpox) is a large, complex double-stranded DNA (dsDNA) virus belonging to Poxviridae.

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

Catastrophism was explained by:

CORE CONCEPT & DERIVATION

Catastrophism is the geological theory that Earth's geological features and biological fossil layers were formed by sudden, violent global events.

Formula / Rule / Reaction:

Factual recall / History of evolutionary thought.

Solution:

- Georges Cuvier, a French anatomist and paleontologist, proposed catastrophism to explain boundaries between fossil strata.
- He asserted that each stratum boundary corresponds to a catastrophe (such as a local flood) that eradicated resident species, followed by repopulation.

Why other options are incorrect:

- **Option A:** Alfred Russel Wallace co-discovered the principle of natural selection alongside Charles Darwin.
- **Option C:** Thomas Malthus wrote an essay on population growth that inspired Darwin's concept of survival struggle.
- **Option D:** Charles Darwin formulated the theory of evolution by natural selection and embraced uniformitarianism.

Question #7 Key: (B)BIOLOGY
01. Cell

Plasma membrane is:

CORE CONCEPT & DERIVATION

The fluid mosaic model establishes that biological membranes possess distinct inner and outer leaflets differing in lipid and protein composition.

Formula / Rule / Reaction:

Membrane asymmetry: Outer leaflet contains glycolipids and phosphatidylcholine; inner leaflet contains phosphatidylserine and phosphatidylethanolamine.

Solution:

- The two halves of the lipid bilayer contain unequal distributions of phospholipids.
- Carbohydrate chains (glycoproteins and glycolipids) are located exclusively on the exoplasmic face, conferring structural and functional asymmetry.

Why other options are incorrect:

- **Option A:** Biological membranes exhibit no bi-radial symmetry across their transverse or lateral planes.
- **Option C:** Radial symmetry does not apply to planar fluid-mosaic molecular assemblies.
- **Option D:** Bilateral symmetry requires mirror-image halves, whereas the inner and outer membrane leaflets are distinct.

Question #8 Key: (B)BIOLOGY
07. Circulation / Transport

How many valves are present in a human heart?

CORE CONCEPT & DERIVATION

The human heart relies on four internal valves to enforce unidirectional blood flow through its chambers.

Formula / Rule / Reaction:

$$\text{Heart Valves} = 2 \text{ Atrioventricular (AV) Valves} + 2 \text{ Semilunar (SL) Valves} = 4$$

Solution:

- The two atrioventricular valves are the tricuspid valve (right side) and the bicuspid/mitral valve (left side).
- The two semilunar valves are the pulmonary valve (pulmonary trunk) and the aortic valve (base of aorta).

Why other options are incorrect:

- **Option A:** Two accounts only for either the AV valves or the semilunar valves, not the entire heart.
- **Option C:** Three accounts for the number of cusps in the tricuspid or semilunar valves, not the total number of valves.
- **Option D:** Six exceeds the four functional cardiac valves present in normal human anatomy.

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

Among chemical substances found in living organisms, water, acids, bases, and salts are classified...

CORE CONCEPT & DERIVATION

Biological compounds are broadly segregated into organic molecules (carbon-hydrogen based) and inorganic molecules.

Formula / Rule / Reaction:

Inorganic compounds lack covalent hydrocarbon (C-H) backbones.

Solution:

- Water (H₂O), mineral acids (such as HCl), bases (such as NaOH), and mineral salts (such as NaCl) lack carbon-carbon or carbon-hydrogen bonds.
- They are therefore classified as inorganic constituents of protoplasm.

Why other options are incorrect:

- **Option A:** All biological matter consists of chemicals, making this term overly broad and non-diagnostic.
- **Option C:** Water and mineral ions are chemical substances, not purely physical constructs.
- **Option D:** Organic compounds require carbon linked covalently to hydrogen, oxygen, or nitrogen (e.g., carbohydrates, lipids, proteins).

Question #10 Key: (A)BIOLOGY
07. Circulation / Transport

Casparian strips are present in:

CORE CONCEPT & DERIVATION

The endodermis of plant roots contains specialized waterproof bands that regulate radial water and ion transport into the vascular cylinder.

Formula / Rule / Reaction:

Apoplast pathway → Blocked by Suberin Casparian strip → Directed to Symplast pathway.

Solution:

- The Casparian strip is a band of cell wall material chemically impregnated with suberin and lignin.
- It is located within the radial and transverse walls of root endodermal cells, preventing passive apoplastic diffusion into the stele.

Why other options are incorrect:

- **Option B:** Cortical cells are parenchymatous with large intercellular spaces and lack suberized wall bands.
- **Option C:** The pericycle lies directly interior to the endodermis and gives rise to lateral roots; it does not contain Casparian strips.
- **Option D:** The epidermis forms the outermost root boundary, producing root hairs for absorption.

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

Which is the function associated with the Golgi apparatus?

CORE CONCEPT & DERIVATION

The Golgi complex acts as the sorting, packaging, and biochemical modification hub for materials received from the endoplasmic reticulum.

Formula / Rule / Reaction:

Proteins/Lipids (from ER) + Carbohydrate moieties $\xrightarrow{\text{Golgi enzymes}}$ Glycoproteins / Glycolip

Solution:

- Proteins and lipids synthesized in the rough and smooth ER enter the cis face of the Golgi apparatus.
- Within the cisternae, enzymes carry out glycosylation, phosphorylation, and proteolytic cleavage before sorting them into secretory vesicles.

Why other options are incorrect:

- **Option B:** Protein synthesis is carried out by ribosomes (either free or membrane-bound on the rough ER).
- **Option C:** Nerve impulse transmission is mediated by plasma membrane ion channels and synaptic terminal machinery.
- **Option D:** Detoxification of drugs and xenobiotics is performed by the smooth endoplasmic reticulum via cytochrome P450 enzymes.

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

Cerebrospinal Fluid (CSF) is found between:

CORE CONCEPT & DERIVATION

The meninges protect the central nervous system across three layers: dura mater, arachnoid mater, and pia mater. Cerebrospinal fluid circulates within the subarachnoid space.

Formula / Rule / Reaction:

Meningeal order (superficial to deep): Dura mater → Subdural space → Arachnoid mater → Subarachnoid space (CSF) → Pia mater.

Solution:

- The subarachnoid space separates the delicate arachnoid mater from the innermost pia mater.
- This space is filled with CSF, providing mechanical cushioning, buoyancy, and metabolic waste clearance for the brain and spinal cord.

Why other options are incorrect:

- **Option A:** The pia and dura are separated by the intermediate arachnoid layer.
- **Option B:** The space between dura and arachnoid is the subdural space, which normally contains only a thin film of serous fluid.
- **Option D:** The space between cranium and dura is the epidural space, which contains adipose tissue and blood vessels in the spinal column.

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

The butterfly-shaped central part of the spinal cord is composed of a special structure known as...

CORE CONCEPT & DERIVATION

Cross-sections of the spinal cord show a centrally positioned grey matter mass surrounded by peripheral white matter.

Formula / Rule / Reaction:

Spinal cord: Central 'H' or butterfly core = Grey matter (unmyelinated cell bodies); Periphery = White matter (myelinated tracts).

Solution:

- The central H-shaped or butterfly-shaped region contains neuron cell bodies, dendrites, interneurons, and unmyelinated axons, designated as grey matter.
- The surrounding white matter consists of ascending and descending columns of myelinated nerve fibers.

Why other options are incorrect:

- Option B:** White matter surrounds the butterfly-shaped central core and contains myelinated tracts.
- Option C:** The butterfly shape specifically delimits grey matter, not both tissue types together.
- Option D:** Neuroglial protein is a molecular component, not a morphological anatomical structure.

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

Which one is a chemotherapeutic agent to destroy and stop the growth of bacteria?

CORE CONCEPT & DERIVATION

Chemotherapeutic agents are antimicrobial substances that can be administered systemically with selective toxicity against pathogens without causing host tissue destruction.

Formula / Rule / Reaction:

Penicillin → Inhibits transpeptidase enzyme → Halts peptidoglycan cross-linking → Cell wall lysis.

Solution:

- Penicillin is a beta-lactam antibiotic derived from *Penicillium* fungi that selectively blocks bacterial cell wall synthesis.
- Because human cells lack a peptidoglycan wall, penicillin acts systemically as a safe chemotherapeutic agent.

Why other options are incorrect:

- Option A:** Phenol is a harsh chemical disinfectant and antiseptic that causes general protein denaturation and is toxic for internal use.
- Option B:** Spirit (ethyl alcohol) is a topical antiseptic and disinfectant, not an internal chemotherapeutic drug.
- Option D:** Sulphuric acid is a corrosive mineral acid that destroys all biological tissue non-selectively.

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

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

CORE CONCEPT & DERIVATION

The troponin complex is a heterotrimeric regulatory protein complex situated on the thin actin filaments of striated muscle.

Formula / Rule / Reaction:

Troponin subunits: Tn-C (binds Ca^{2+}), Tn-I (binds actin), Tn-T (binds tropomyosin).

Solution:

- Troponin subunit C binds calcium ions released by the sarcoplasmic reticulum.
- Troponin subunit I binds actin to anchor the inhibitory complex.
- Troponin subunit T binds tropomyosin to shift its position off the myosin-binding sites.
- Troponin never directly interacts with or binds to myosin cross-bridges.

Why other options are incorrect:

- Option A:** Troponin I directly binds actin in resting muscle fibers.
- Option C:** Troponin T directly binds and anchors the complex to tropomyosin.
- Option D:** Troponin C possesses high-affinity binding sites for divalent calcium cations.

Question #16 Key: (C)BIOLOGY
10. Homeostasis

With reference to female reproduction, the exchange of which material is non-placental?

CORE CONCEPT & DERIVATION

The placenta functions as a selective exchange barrier through which maternal and fetal circulations approach closely without cellular mixing.

Formula / Rule / Reaction:

Hemochorial placental barrier: Maternal blood and fetal erythrocytes do not cross under physiological conditions.

Solution:

- The placental barrier separates maternal blood in the intervillous spaces from fetal blood within chorionic villus capillaries.
- Nutrients, respiratory gases (O_2 , CO_2), and nitrogenous wastes cross by passive diffusion and active transport, but whole blood does not mix directly.

Why other options are incorrect:

- Option A:** Metabolic wastes (such as urea, creatinine, and uric acid) readily diffuse across the placental membrane into maternal blood.
- Option B:** Oxygen and carbon dioxide cross the placental barrier efficiently via simple diffusion.
- Option D:** Nutrients including glucose, amino acids, and water-soluble vitamins are actively transported across the placenta.

Question #17 Key: (A)BIOLOGY
02. Biomolecules*The largest group in the animal kingdom is:***CORE CONCEPT & DERIVATION**

Phylum Arthropoda constitutes the most diverse and numerous taxonomic group in the animal kingdom.

Formula / Rule / Reaction:

Arthropoda > 80% of all known animal species (over 1 million described species, largely Class Insecta).

Solution:

- Arthropods possess jointed appendages, chitinous exoskeletons, and segmented bodies.
- Their evolutionary adaptations have enabled extensive colonization of terrestrial, marine, and freshwater biomes, making them the largest phylum.

Why other options are incorrect:

- **Option B:** Mammals represent a single class within Chordata comprising roughly 6,500 species.
- **Option C:** Mollusca is the second largest animal phylum with roughly 100,000 described species.
- **Option D:** Nematoda contains roughly 25,000 to 100,000 recognized roundworm species, far fewer than Arthropoda.

Question #18 Key: (D)BIOLOGY
16. Evolution*The different members of colonies in coelenterates that perform different functions are:***CORE CONCEPT & DERIVATION**

Colonial cnidarians (such as Obelia or Physalia) exhibit polymorphism, where the colony is comprised of morphologically specialized individuals.

Formula / Rule / Reaction:

Polymorphic colony components = Zooids (e.g., Gastrozooids, Gonozooids, Dactylozooids).

Solution:

- In colonial coelenterates, individual organisms integrated into the common coenosarc are called zooids.
- Different zooids undergo structural specialization: gastrozooids for feeding, gonozooids for reproduction, and dactylozooids for defense.

Why other options are incorrect:

- **Option A:** Workers are sterile female castes found in eusocial insect colonies (Hymenoptera: bees, ants).
- **Option B:** Drones are fertile male castes found in social insect colonies.
- **Option C:** Zooplankton is an ecological category describing passively drifting aquatic microscopic organisms.

Question #19 Key: (C)BIOLOGY
09. Respiration / Gaseous Exchange*Which of the following is incorrect about lungs?***CORE CONCEPT & DERIVATION**

Respiratory organs display broad evolutionary diversity across living taxa, with lungs being restricted to air-breathing vertebrates and certain specialized invertebrates.

Formula / Rule / Reaction:

Factual recall / Comparative animal physiology.

Solution:

- Lungs are absent in fish (which use gills), insects (which use tracheal tubes), earthworms (cutaneous respiration), and all single-celled organisms.
- Therefore, the assertion that lungs are the respiratory organ of all organisms is factually incorrect.

Why other options are incorrect:

- **Option A:** Human lungs are anatomically situated within the intrathoracic (chest) cavity on either side of the mediastinum.
- **Option B:** The human lungs are slightly unequal in size; the right lung has three lobes and is larger, while the left lung has two lobes to accommodate the cardiac notch.
- **Option D:** Each lung is enclosed by a double-layered serous membrane called the pleura (visceral and parietal layers).

Question #20 Key: (A)BIOLOGY
07. Circulation / Transport*Which of the following is responsible for producing the 'LUB DUB' sound of the heart?***CORE CONCEPT & DERIVATION**

Heart sounds heard via auscultation are caused by blood turbulence generated upon the rapid closure of heart valves.

Formula / Rule / Reaction:

First sound (Lub) = Closure of AV valves (Tricuspid/Bicuspid)

Second sound (Dub) = Closure of Semilunar valves (Aortic/Pulmonary)

Solution:

- The first heart sound (lub) occurs during ventricular systole when the atrioventricular valves snap shut.
- The second heart sound (dub) occurs during early ventricular diastole when backpressure in the great arteries snaps the semilunar valves shut.

Why other options are incorrect:

- **Option B:** Atrial contraction produces a soft, inaudible atrial gallop (S4 in pathological states) but does not produce the physiological lub-dub.
- **Option C:** Muscle fiber contraction generates electrical currents detected on an ECG, but not the audible mechanical heart sounds.
- **Option D:** Ventricular contraction drives intraventricular pressure upward, but the sound itself arises directly from the valve leaflets snapping shut.

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

What are capsomeres composed of?

CORE CONCEPT & DERIVATION

A viral capsid is the protective protein shell that encloses the viral nucleic acid core.

Formula / Rule / Reaction:

Capsid = Assembly of repetitive protein structural subunits (Capsomeres).

Solution:

- Capsomeres are individual proteinaceous subunits arranged in geometrical arrays (helical or icosahedral) around the viral genome.
- These subunits are encoded by the viral genome and fold into specific tertiary structures that spontaneously assemble into the complete capsid.

Why other options are incorrect:

- **Option A:** Carbohydrates occur in viral glycoproteins of enveloped viruses, but do not constitute the structural capsomeres.
- **Option B:** Lipids are acquired by enveloped viruses from host cell membranes during budding; capsomeres themselves contain no lipids.
- **Option C:** Lipoproteins are lipid-protein conjugates found in membranes, not the fundamental building blocks of basic capsids.

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

After ovulation, the ruptured follicle is transformed into a glandular mass called:

CORE CONCEPT & DERIVATION

Following the luteinizing hormone (LH) surge and oocyte release, the remaining granulosa and theca cells of the ruptured ovarian follicle undergo luteinization.

Formula / Rule / Reaction:Ruptured Graafian Follicle $\xrightarrow{\text{LH surge}}$ Corpus Luteum $\rightarrow$ Secretes Progesterone.**Solution:**

- After releasing the secondary oocyte, the collapsed follicle wall hypertrophies into a temporary endocrine gland known as the corpus luteum (yellow body).
- The corpus luteum actively secretes progesterone and estrogen to prepare and maintain the endometrium for potential blastocyst implantation.

Why other options are incorrect:

- **Option A:** The Graafian follicle is the mature, fluid-filled pre-ovulatory ovarian follicle prior to rupture.
- **Option B:** Corpus allatum is an endocrine gland located in insects that secretes juvenile hormone.
- **Option C:** Primary follicles are early, immature ovarian structures consisting of a primary oocyte surrounded by a single layer of cuboidal granulosa cells.

Question #23 Key: (A)BIOLOGY
02. Biomolecules

Tristearin is a/an:

CORE CONCEPT & DERIVATION

Triglycerides are neutral lipids consisting of a glycerol molecule esterified to three fatty acid chains.

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

- Tristearin (glyceryl tristearate, $\text{C}_{57}\text{H}_{110}\text{O}_6$) is a simple triglyceride derived from glycerol and three stearic acid molecules.
- Because it is an ester of fatty acids and glycerol, it belongs to the lipid family.

Why other options are incorrect:

- **Option B:** Proteins are polymers of amino acids linked together via peptide bonds.
- **Option C:** Enzymes are biocatalysts, almost universally globular proteins or catalytic RNAs (ribozymes).
- **Option D:** Amino acids are organic monomers containing an alpha-carbon, an amino group, a carboxyl group, and a variable R group.

Question #24 Key: (C)BIOLOGY
15. Inheritance / Variation & GeneticsWhat will be the F₂ phenotypic ratio if a red-flowered male plant is bred with a white-flowered...**CORE CONCEPT & DERIVATION**In classical Mendelian monohybrid crosses involving complete dominance, crossing true-breeding dominant and recessive parents yields an F₂ phenotypic ratio of 3:1.**Formula / Rule / Reaction:**

$$P_1 : RR \times rr \Rightarrow F_1 : Rr \quad (\text{All Red})$$

$$F_1 \times F_1 : Rr \times Rr \Rightarrow F_2 : 1RR : 2Rr : 1rr \Rightarrow 3 \text{ Red} : 1 \text{ White}$$

Solution:

- Parent generation cross produces uniform heterozygous F₁ progeny with the dominant red phenotype (Rr).
- Self-fertilization or interbreeding of F₁ individuals generates the F₂ generation with genotypes $1RR : 2Rr : 1rr$.
- Because RR and Rr both display the red flower phenotype, the resulting phenotypic ratio is 3 red to 1 white.

Why other options are incorrect:

- **Option A:** 1:2 represents an incomplete ratio, sometimes seen in lethal allele systems (1:2:0).
- **Option B:** 1:1 is the expected phenotypic ratio resulting from a testcross between a heterozygote (Rr) and a homozygous recessive (rr).
- **Option D:** 1:3 inverts the dominance relationship, which would only occur if white were dominant.

Question #25 Key: (A)BIOLOGY
02. Biomolecules*Upon hydrolysis, cellulose yields:***CORE CONCEPT & DERIVATION**

Cellulose is an unbranched polymer of β -D-glucose units joined by $\beta(1 \rightarrow 4)$ -glycosidic bonds. Intermediate enzymatic hydrolysis yields its fundamental repeating disaccharide unit.

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

- The repeating unit of cellulose consists of two β -D-glucose molecules linked by a $\beta(1 \rightarrow 4)$ bond, designated as cellobiose.
- Upon partial chemical or enzymatic digestion, cellulose breaks down into cellobiose units prior to ultimate conversion into free glucose.

Why other options are incorrect:

- Option B:** Cellobiose is chemically a disaccharide containing two glucose residues, not a trisaccharide.
- Option C:** Cellulose is a homopolysaccharide composed solely of glucose; galactose is an epimer not found in cellulose.
- Option D:** Maltose is a disaccharide containing two α -D-glucose units linked by an $\alpha(1 \rightarrow 4)$ bond, derived from starch hydrolysis.

Question #26 Key: (D)BIOLOGY
05. Acellular Life*HIV belongs to which group of viruses?***CORE CONCEPT & DERIVATION**

Retroviruses are enveloped RNA viruses that use the enzyme reverse transcriptase to transcribe their RNA genome into complementary DNA.

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

- HIV (Human Immunodeficiency Virus) belongs to the genus Lentivirus within the family Retroviridae.
- It contains two identical copies of single-stranded positive-sense RNA and encodes reverse transcriptase, integrase, and protease enzymes.

Why other options are incorrect:

- Option A:** HIV possesses an RNA genome, not a DNA genome.
- Option B:** HIV is enveloped, but its primary genetic material is RNA, not DNA.
- Option C:** Protein tumor virus is not a recognized virological classification; oncoviruses are nucleic acid containing viruses.

Question #27 Key: (D)BIOLOGY
01. Cell*Which cell type does not have histones with DNA to make chromosomes?***CORE CONCEPT & DERIVATION**

Prokaryotic organisms possess circular DNA molecules that are compacted by nucleoid-associated proteins (NAPs) rather than true eukaryotic histone octamers.

Formula / Rule / Reaction:

Eukaryotes: DNA wrapped around histone octamer (H2A, H2B, H3, H4) → Nucleosome. Bacteria lack true histone proteins.

Solution:

- Bacteria are prokaryotes whose chromosome is a closed circular DNA duplex located in the nucleoid.
- Bacterial DNA is packaged with polyamines and non-histone architectural proteins (such as HU and H-NS), lacking standard eukaryotic histone proteins.

Why other options are incorrect:

- Option A:** Fungi are true eukaryotes whose linear genomic DNA is complexed with classical histone proteins.
- Option B:** Plant cells are eukaryotic and assemble their nuclear DNA into chromatin using histone complexes.
- Option C:** Animal cells are eukaryotic and rely on core histones to form nucleosomes and higher-order chromatin fibers.

Question #28 Key: (C)BIOLOGY
11. Support & Movement*Lactic acid accumulation in skeletal muscle cells causes:***CORE CONCEPT & DERIVATION**

During strenuous anaerobic exercise, glycolytic production of lactic acid lowers intracellular pH, contributing to the physiological phenomenon of muscle fatigue.

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

- Anaerobic glycolysis leads to the accumulation of lactate and protons (H^+) within myocytes.
- The resulting cellular acidosis impairs enzyme function (such as phosphofructokinase) and interferes with calcium release and troponin binding, resulting in muscle fatigue.

Why other options are incorrect:

- Option A:** Muscular atrophy is a structural reduction in muscle mass and myofibrillar protein caused by prolonged disuse, denervation, or malnutrition.
- Option B:** Muscle cramps are sustained, painful involuntary spasms typically linked to severe dehydration, motor neuron hyperexcitability, or electrolyte imbalances.
- Option D:** Muscle tetany is a condition of sustained maximal contraction caused by repetitive high-frequency stimulation or hypocalcemia.

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

In how many stages is the HIV infection process divided?

CORE CONCEPT & DERIVATION

Clinically and pathologically, untreated HIV infection progresses through three distinct, well-defined chronological stages.

Formula / Rule / Reaction:

Stage 1: Acute HIV infection → Stage 2: Chronic HIV infection (Clinical latency) → Stage 3: Acquired Immunodeficiency Syndrome (AIDS).

Solution:

- Stage 1 (Acute Infection): Flu-like illness with high viremia occurring 2 to 4 weeks post-exposure.
- Stage 2 (Clinical Latency / Chronic Stage): Low-level viral replication and gradual decline of CD4⁺ T-lymphocyte counts over several years.
- Stage 3 (AIDS): Severe immunodeficiency where CD4⁺ counts drop below 200 cells/ μ L or opportunistic infections appear.

Why other options are incorrect:

- **Option A:** HIV is not a single-stage disease; it evolves through acute, latent, and terminal immunodeficiency phases.
- **Option B:** Two stages ignores either the acute primary seroconversion phase or the asymptomatic clinical latency phase.
- **Option D:** Although older WHO clinical staging had four stages based on symptomatology, standard textbook and CDC frameworks divide HIV infection into three primary pathophysiological stages.

Question #30 Key: (A)BIOLOGY
04. Bioenergetics

What is the color of Chlorophyll-a molecules?

CORE CONCEPT & DERIVATION

Photosynthetic pigments exhibit distinct absorption spectra and reflected colors based on minor structural variations in their porphyrin-like ring systems.

Formula / Rule / Reaction:Chlorophyll a (with methyl –CH₃ group): Appears blue-green.
Chlorophyll b (with formyl –CHO group): Appears yellow-green.**Solution:**

- Chlorophyll a predominantly absorbs red and blue-violet wavelengths, reflecting light in the blue-green portion of the visible spectrum.
- Paper chromatography readily resolves chlorophyll a as a blue-green band and chlorophyll b as a yellow-green band.

Why other options are incorrect:

- **Option B:** Yellowish-green is the characteristic reflected color of chlorophyll b.
- **Option C:** Dark green is an imprecise general term, not the specific chromatographic description of chlorophyll a.
- **Option D:** Photosynthetic pigments in plants do not display reddish-green coloration.

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

The thick filament, which is 16nm in diameter, is composed of?

CORE CONCEPT & DERIVATION

Myofibrils in striated muscle tissue are composed of two main types of myofilaments: thick filaments and thin filaments.

Formula / Rule / Reaction:Thick filaments = Myosin (diameter $\approx$ 16 nm).
Thin filaments = Actin + Tropomyosin + Troponin (diameter $\approx$ 7 – 8 nm).**Solution:**

- Thick filaments measure roughly 16 nm in diameter and are composed of several hundred organized motor proteins known as myosin.
- Each myosin molecule is a hexamer consisting of two heavy chains that form a coiled-coil tail and two pairs of light chains forming globular heads.

Why other options are incorrect:

- **Option A:** Actin forms the main structural helical backbone of the thin filaments (7 to 8 nm diameter).
- **Option C:** Tropomyosin is a fibrous protein that wraps around the actin filament in the thin filaments.
- **Option D:** Troponin is a globular regulatory complex attached to tropomyosin along the thin filaments.

Question #32 Key: (A)BIOLOGY
03. Enzymes

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

CORE CONCEPT & DERIVATIONEnzymes accelerate biochemical reactions by reducing the Gibbs free energy of activation ($\Delta G^\ddagger$). This is achieved by creating an optimal microenvironment within the catalytic active site.**Formula / Rule / Reaction:**

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

Solution:

- The catalytic active site provides precise chemical conditions: favorable local pH, electrostatic interactions, temporary covalent bonds, and substrate strain.
- These altered microenvironmental conditions stabilize the unstable high-energy transition state, lowering the activation energy barrier.

Why other options are incorrect:

- **Option B:** The overall tertiary framework provides structural scaffolding, but catalysis is governed directly by amino acid side chains within the active site cavity.
- **Option C:** Active sites are composed of specific amino acid residues, not fatty acids.
- **Option D:** Distorting molecules in the allosteric site regulates enzyme activity (allosteric inhibition or activation), but does not direct primary catalytic transition-state stabilization.

Question #33 Key: (D)BIOLOGY
16. Evolution

Which among the following permits interbreeding among individuals of the same species?

CORE CONCEPT & DERIVATION

The biological species concept defines a species as a group of interbreeding natural populations that are reproductively isolated from other such groups. Sharing a geographic niche or habitat is a prerequisite for natural mating.

Formula / Rule / Reaction:

Sympatry / Shared habitat $\Rightarrow$ Physical encounter $\Rightarrow$ Gene flow via interbreeding.

Solution:

- For individuals of sexually reproducing organisms to interbreed in nature, they must share a common habitat or geographic distribution (sympatry).
- Living within the same ecological niche permits physical encounter, courtship, and copulation, maintaining panmixia and gene flow.

Why other options are incorrect:

- Option A:** Reproductive isolation prevents interbreeding between different populations or species, driving speciation rather than permitting mating.
- Option B:** Mutation creates novel alleles, but does not itself provide the physical opportunity for mating.
- Option C:** Chromosomal aberrations often cause meiotic defects and gametic incompatibility, reducing interbreeding success.

Question #34 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

When do anti-A and anti-B antibodies appear in plasma?

CORE CONCEPT & DERIVATION

Naturally occurring ABO blood group antibodies (isoagglutinins) are not present at birth in neonates, but develop within the first few months postpartum.

Formula / Rule / Reaction:

Exposure to gut bacteria sharing A/B-like oligosaccharides $\rightarrow$ Synthesis of anti-A and anti-B IgM antibodies at 2 to 8 months of age.

Solution:

- Newborn infants possess only maternal IgG antibodies acquired across the placenta.
- As the infant's gut is colonized by normal bacterial flora containing polysaccharide antigens structurally similar to A and B antigens, immune stimulation triggers the production of anti-A and anti-B antibodies between 2 and 6 months of age.

Why other options are incorrect:

- Option A:** The fetus does not synthesize anti-A or anti-B antibodies during early intrauterine development.
- Option C:** Puberty occurs around 10 to 14 years of age; ABO isoagglutinins reach peak titers around 8 to 10 years of age and originate in infancy.
- Option D:** Unlike Rh antibodies (which require deliberate transfusion or fetal exposure to Rh+ cells), ABO antibodies arise naturally without blood transfusion.

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

Which of the following is NOT an event of light-dependent reactions during photosynthesis?

CORE CONCEPT & DERIVATION

Photosynthesis consists of thylakoid-associated light-dependent reactions and stroma-associated light-independent reactions (Calvin cycle).

Formula / Rule / Reaction:

Light reactions: $12\text{H}_2\text{O} + 12\text{NADP}^+ + 18\text{ADP} + 18\text{P}_i \xrightarrow{h\nu} 6\text{O}_2 + 12\text{NADPH} + 18\text{ATP}$

Dark reactions: $6\text{CO}_2 + 18\text{ATP} + 12\text{NADPH} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 18\text{ADP} + 12\text{NADP}^+ + 6\text{H}_2\text{O}$

Solution:

- Photolysis of water, electron transport, photophosphorylation (ATP synthesis), and reduction of NADP^+ occur in the thylakoid membranes during the light reactions.
- Carbon dioxide fixation and its enzymatic reduction into carbohydrates occur in the stroma during the light-independent Calvin cycle.

Why other options are incorrect:

- Option A:** Photolysis of water occurs at Photosystem II within the thylakoid lumen during the light reactions.
- Option B:** ATP synthesis driven by proton motive force (photophosphorylation) is a central event of light reactions.
- Option D:** Ferredoxin-NADP+ reductase reduces NADP^+ to NADPH at the stromal side of the thylakoid during light reactions.

Question #36 Key: (B)BIOLOGY
11. Support & Movement

What are the living cells of cartilage called?

CORE CONCEPT & DERIVATION

Cartilage is a specialized avascular connective tissue containing mature cells embedded within small spaces (lacunae) of an extracellular matrix.

Formula / Rule / Reaction:

Chondroblasts $\rightarrow$ Secretion of matrix $\rightarrow$ Entrapment in lacunae $\rightarrow$ Mature Chondrocytes.

Solution:

- Chondrocytes are the mature, living cellular components of cartilage.
- They maintain the cartilaginous extracellular matrix consisting of collagen fibers, elastin, and proteoglycans (chondroitin sulfate).

Why other options are incorrect:

- Option A:** Astrocytes are star-shaped glial cells that support neurons and form the blood-brain barrier in the central nervous system.
- Option C:** Osteocytes are mature living cells embedded in the mineralized matrix of bone.
- Option D:** Melanocytes are specialized pigment-producing cells located in the stratum basale of the epidermis.

Question #37 Key: (D)BIOLOGY
01. Cell

In prokaryotic cells, which one of the following organelles is present?

CORE CONCEPT & DERIVATION

Prokaryotic cells lack all membrane-bound internal organelles, but possess non-membrane-bound ribonucleoprotein complexes for translation.

Formula / Rule / Reaction:

Prokaryotic translation machinery = 70S Ribosome (50S large subunit + 30S small subunit).

Solution:

- Prokaryotic cytoplasm contains 70S ribosomes distributed freely throughout the cytosol.
- These structures carry out protein synthesis, but lack a surrounding lipid bilayer membrane.

Why other options are incorrect:

- **Option A:** Mitochondria are double-membrane-bound eukaryotic organelles absent in prokaryotes.
- **Option B:** The nucleus is a double-membrane-enclosed eukaryotic organelle; prokaryotic DNA resides naked in the nucleoid.
- **Option C:** The Golgi apparatus is a eukaryotic endomembrane organelle responsible for protein trafficking.

Question #38 Key: (B)BIOLOGY
04. Bioenergetics

Phycocyanin is a pigment present in cyanobacteria. Phycocyanin is of _____ color.

CORE CONCEPT & DERIVATION

Phycobiliproteins are water-soluble accessory photosynthetic pigments found in cyanobacteria and red algae.

Formula / Rule / Reaction:

Phycocyanin: Absorbs orange-red light ($\approx 620 \text{ nm}$); reflects blue light.
Phycocerythrin: Reflects red light.

Solution:

- Phycocyanin is a distinct blue pigment-protein complex found in cyanobacteria (blue-green algae).
- Alongside green chlorophyll a, phycocyanin imparts the characteristic blue-green appearance to these photosynthetic prokaryotes.

Why other options are incorrect:

- **Option A:** Green is the color of chlorophyll a and chlorophyll b.
- **Option C:** Yellow is the reflected color of carotenoids (xanthophylls).
- **Option D:** Red is the reflected color of phycocerythrin, an accessory phycobilin dominant in Rhodophyta.

Question #39 Key: (C)BIOLOGY
07. Circulation / Transport

The flow of lymph is always towards _____?

CORE CONCEPT & DERIVATION

The lymphatic vascular system is an open, unidirectional drainage network that collects interstitial fluid and returns it to the venous circulation.

Formula / Rule / Reaction:

Lymphatic capillaries → Vessels → Lymph Nodes → Thoracic Duct / Right Lymphatic Duct → Subclavian Veins.

Solution:

- Lymphatic vessels contain one-way valves that prevent backflow, directing fluid centrally.
- Lymph from the lower body, left arm, left side of the head, and thorax converges into the thoracic duct, which drains into the left subclavian vein.

Why other options are incorrect:

- **Option A:** Carotid arteries carry high-pressure, oxygenated blood from the aorta to the head; lymph does not drain into the arterial system.
- **Option B:** Iliac arteries carry arterial blood to the pelvis and lower limbs.
- **Option D:** The thymus gland is a primary lymphoid organ for T-cell maturation, not a terminal drainage reservoir for systemic lymph.

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

Fossil of Cro-Magnon was collected from?

CORE CONCEPT & DERIVATION

Cro-Magnon man represents early anatomically modern humans (Homo sapiens) inhabiting the European Upper Paleolithic.

Formula / Rule / Reaction:

Factual recall / Human evolutionary paleontology.

Solution:

- The first Cro-Magnon skeletal remains were discovered in 1868 by Édouard Lartet at the Abri de Cro-Magnon rock shelter.
- This site is located in Les Eyzies-de-Tayac in southwestern France.

Why other options are incorrect:

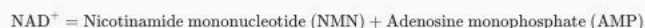
- **Option A:** South America contains ancient indigenous human remains, but no Cro-Magnon Paleolithic type-specimens.
- **Option B:** Important fossil hominids have been found in Britain (e.g., Swanscombe, Red Lady of Paviland), but not the Cro-Magnon type.
- **Option C:** Ireland has no Upper Paleolithic Cro-Magnon fossil discoveries.

Question #41 Key: (B)BIOLOGY
03. Enzymes

NAD is a:

CORE CONCEPT & DERIVATION

Nicotinamide adenine dinucleotide (NAD) is a central metabolic coenzyme composed of two nucleotide residues joined by their phosphate groups.

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

- One nucleotide contains a nicotinamide base linked to ribose and phosphate.
- The second nucleotide contains an adenine base linked to ribose and phosphate.
- These two units are joined via a pyrophosphate bridge, defining NAD as a dinucleotide.

Why other options are incorrect:

- **Option A:** Mononucleotides contain a single nitrogenous base, pentose sugar, and phosphate (e.g., AMP, CMP).
- **Option C:** Trinucleotides are oligomers composed of three covalently linked nucleotides.
- **Option D:** Polynucleotides are extended polymers such as RNA and DNA comprising many repeating nucleotides.

Question #42 Key: (B)BIOLOGY
14. Reproduction

Which of the following is a viral sexually transmitted disease?

CORE CONCEPT & DERIVATION

Sexually transmitted infections (STIs) are categorized etiologically into viral, bacterial, protozoal, and fungal pathologies.

Formula / Rule / Reaction:

Herpes Simplex Virus Type 2 (HSV-2) → Genital Herpes (Viral STI).

Solution:

- Genital herpes is an STI caused by the Herpes Simplex Virus (predominantly HSV-2, and occasionally HSV-1).
- Because HSV is an enveloped double-stranded DNA virus, genital herpes is classified as a viral sexually transmitted disease.

Why other options are incorrect:

- **Option A:** Dengue is an arboviral infection transmitted through the bite of female Aedes aegypti mosquitoes, not sexually.
- **Option C:** Gonorrhea is an STI caused by the Gram-negative diplococcus bacterium Neisseria gonorrhoeae.
- **Option D:** Syphilis is an STI caused by the spirochete bacterium Treponema pallidum.

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

In prokaryotes, the function of mitochondria is performed by which one of the following?

CORE CONCEPT & DERIVATION

Because prokaryotic cells lack membrane-bound organelles, oxidative phosphorylation occurs across specialized invaginations of their plasma membrane.

Formula / Rule / Reaction:

Mesosome / Infolded plasma membrane contains electron transport chains and ATP synthase machinery.

Solution:

- Mesosomes are convoluted invaginations of the prokaryotic plasma membrane.
- They increase surface area and harbor electron transport system enzymes, thereby serving respiratory functions analogous to mitochondrial cristae.

Why other options are incorrect:

- **Option B:** The periplasm is the gel-filled space between the inner cytoplasmic membrane and the outer membrane in Gram-negative bacteria.
- **Option C:** Ribosomes carry out protein translation, not cellular respiration.
- **Option D:** Plasmids are small, extrachromosomal circular DNA duplexes carrying accessory genes like antibiotic resistance.

Question #44 Key: (D)BIOLOGY
03. Enzymes

Sterilization of blood products is carried out by?

CORE CONCEPT & DERIVATION

Blood products, immunoglobulins, and vaccines contain heat-labile proteins that denature when exposed to autoclaving, boiling, or harsh chemicals. Ionizing radiation or UV irradiation is used for pathogen inactivation.

Formula / Rule / Reaction:

Gamma irradiation / Ionizing radiation → Breaks microbial DNA without causing thermal denaturation of plasma proteins.

Solution:

- Gamma rays and high-energy electron beams penetrate biological packaging without generating destructive heat.
- Ionizing radiation damages microbial and viral genetic material while preserving the functional integrity of fragile serum proteins and blood factors.

Why other options are incorrect:

- **Option A:** Harsh chemical sterilants (like formalin or ethylene oxide) can cross-react with and denature functional plasma proteins or leave toxic residues.
- **Option B:** Desiccation or drying causes protein precipitation and does not reliably destroy bacterial endospores or naked viruses.
- **Option C:** Heat (autoclaving or dry heat) coagulates and denatures blood proteins.

Question #45 Key: (D)BIOLOGY
13. Chemical Coordination*Which hormone controls the release of milk from the mammary glands?***CORE CONCEPT & DERIVATION**

Lactation involves two hormonal reflexes: prolactin stimulates milk synthesis, whereas oxytocin mediates the milk ejection reflex.

Formula / Rule / Reaction:

Suckling stimulus → Sensory afferents to Hypothalamus → Posterior Pituitary releases Oxytocin → Contraction of myoepithelial cells → Milk ejection.

Solution:

- Oxytocin is released from the neurohypophysis in response to mechanical stimulation of the nipple during suckling.
- It induces forceful contraction of the myoepithelial cells surrounding mammary alveoli, forcing stored milk into the lactiferous ducts.

Why other options are incorrect:

- **Option A:** Follicle-stimulating hormone (FSH) promotes follicular growth in ovaries and spermatogenesis in testes.
- **Option B:** Progesterone supports the secretory endometrium during pregnancy and inhibits active lactation until parturition.
- **Option C:** Luteinizing hormone (LH) triggers ovulation and maintains the corpus luteum in females.

Question #46 Key: (B)BIOLOGY
02. Biomolecules*Which of the following is a conjugated molecule?***CORE CONCEPT & DERIVATION**

Conjugated molecules are composite macromolecules formed when two biochemically distinct classes of biomolecules covalently link together.

Formula / Rule / Reaction:

Carbohydrate moiety (Oligosaccharide) + Polypeptide chain $\xrightarrow{\text{Covalent linkage}}$ Glycoprotein

Solution:

- Glycoproteins consist of carbohydrates covalently linked to protein chains.
- Because they integrate two different categories of biomolecules, they are classified as conjugated molecules.

Why other options are incorrect:

- **Option A:** Polysaccharides are simple macromolecules composed exclusively of monosaccharide monomers.
- **Option C:** Glycogen is a homopolysaccharide composed entirely of branched α -D-glucose chains.
- **Option D:** Starch is a plant storage homopolysaccharide composed solely of glucose units (amylose and amylopectin).

Question #47 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics*Who discovered the ABO blood group system?***CORE CONCEPT & DERIVATION**

The human ABO blood group system was established through early hemagglutination experiments showing reciprocal relationships between red blood cell surface antigens and serum isohemagglutinins.

Formula / Rule / Reaction:

Factual recall / History of immunology and genetics.

Solution:

- Austrian physician Karl Landsteiner discovered the A, B, and O blood groups in 1900 to 1901 by mixing erythrocytes and serum from colleagues.
- For this discovery, which made blood transfusion safe, he was awarded the 1930 Nobel Prize in Physiology or Medicine.

Why other options are incorrect:

- **Option A:** Felix Bernstein determined the multiple-allele inheritance pattern (alleles I^A , I^B , i) of the ABO system in 1924.
- **Option B:** Gregor Mendel established the foundational laws of inheritance using pea plants in 1865.
- **Option D:** Philip Levine discovered the clinical significance of the Rh factor and its role in erythroblastosis fetalis.

Question #48 Key: (D)BIOLOGY
02. Biomolecules*As water changes into vapor:***CORE CONCEPT & DERIVATION**

Evaporation is an endothermic phase change that requires absorbing latent heat of vaporization from the local surroundings.

Formula / Rule / Reaction:

Liquid H_2O + ΔH_{vap} → Vapor H_2O ($\Delta H_{\text{vap}} \approx +40.7 \text{ kJ/mol}$ at 100°C)

Solution:

- Only the water molecules possessing the highest kinetic energy overcome intermolecular hydrogen bonding to transition into the gaseous phase.
- As high-energy molecules escape, the average kinetic energy of the remaining liquid and contact surface decreases, producing evaporative cooling.

Why other options are incorrect:

- **Option A:** Molecules in the vapor phase move significantly faster than in the condensed liquid phase.
- **Option B:** Vaporization absorbs thermal energy from the environment, cooling rather than warming it.
- **Option C:** Kinetic energy increases significantly as liquid water transitions into free-moving gas molecules.

Question #49 Key: (D)BIOLOGY
12. Nervous Coordination

What are nerve impulses?

CORE CONCEPT & DERIVATION

A nerve impulse is a propagating wave of transient electrical membrane depolarization fueled by chemical ion movements across the axolemma.

Formula / Rule / Reaction:

Action potential: Rapid flux of Na^+ inward (depolarization) and K^+ outward (repolarization) generates propagating electrical currents.

Solution:

- The electrical aspect consists of potential differences across the membrane during polarization, depolarization, and repolarization.
- The chemical aspect involves the flux of inorganic ions (Na^+ , K^+ , Cl^-) through protein channels and the release of chemical neurotransmitters at synapses.
- Hence, nerve impulses are defined as electrochemical waves.

Why other options are incorrect:

- **Option A:** Electromechanical waves involve mechanical acoustic deformations, whereas axonal conduction is ionic and electrical.
- **Option B:** Electromagnetic waves (such as light or radio waves) consist of oscillating electric and magnetic fields that propagate through a vacuum.
- **Option C:** Electromechno is an invalid non-scientific term.

Question #50 Key: (A)BIOLOGY
04. Bioenergetics

Which one of the following is the direct source of energy in living bodies?

CORE CONCEPT & DERIVATION

Adenosine triphosphate (ATP) functions as the universal chemical energy currency of all biological systems.

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

- While carbohydrates and lipids serve as long-term and intermediate energy stores, their chemical energy must first be converted into ATP via cellular respiration.
- Cellular processes (such as muscle contraction, active transport, and biosynthesis) couple directly to the hydrolysis of the terminal phosphoanhydride bond of ATP.

Why other options are incorrect:

- **Option B:** Glucose is a circulating metabolic fuel that must undergo glycolysis and aerobic respiration to generate ATP; it cannot drive cellular motor proteins directly.
- **Option C:** Amino acids serve primarily as building blocks for proteins and are only oxidized into respiratory intermediates during starvation or excess.
- **Option D:** Fatty acids are high-energy storage substrates that require beta-oxidation in mitochondria to yield acetyl-CoA and subsequent ATP.

Question #51 Key: (A)BIOLOGY
14. Reproduction

Epididymis opens into:

CORE CONCEPT & DERIVATION

The male reproductive tract conducts spermatozoa through an ordered sequence of tubular conduits from the seminiferous tubules to the urethra.

Formula / Rule / Reaction:

Sperm pathway: Seminiferous tubules → Rete testis → Vasa efferentia → Epididymis → Vas deferens → Ejaculatory duct → Urethra.

Solution:

- The tail (cauda) of the epididymis serves as a sperm storage reservoir and directly transitions into the muscular vas deferens (ductus deferens).
- The vas deferens then ascends through the inguinal canal into the abdominal cavity.

Why other options are incorrect:

- **Option B:** The ejaculatory duct is formed later by the union of the vas deferens ampulla and the duct of the seminal vesicle.
- **Option C:** The urinogenital duct (urethra) receives sperm downstream via the ejaculatory ducts within the prostate gland.
- **Option D:** Vasa efferentia emerge from the rete testis and lead into the head (caput) of the epididymis, upstream of the vas deferens.

Question #52 Key: (D)BIOLOGY
15. Inheritance / Variation & Genetics

The phenomenon responsible for genetic variation is:

CORE CONCEPT & DERIVATION

Meiotic recombination shuffles paternal and maternal alleles to produce novel recombinant haplotypes in gametes.

Formula / Rule / Reaction:

Prophase I (Pachytene) → Synaptonemal complex facilitates reciprocal exchange of non-sister chromatid segments → Chiasmata → Recombinant gametes.

Solution:

- Crossing over involves the physical breakage and reciprocal exchange of genetic material between non-sister chromatids of homologous chromosomes during pachytene of prophase I.
- This process breaks ancestral linkage groups and generates novel allele combinations, serving as a primary driver of genetic diversity.

Why other options are incorrect:

- **Option A:** Mitosis is an equational division producing genetically identical daughter cells with zero intentional variation.
- **Option B:** Cloning produces genetically identical organisms or cells, eliminating allelic variation.
- **Option C:** Complete gene linkage preserves parental allele combinations and prevents independent assortment, thereby restricting variation.

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

The infundibulum connects the pituitary gland to the:

CORE CONCEPT & DERIVATION

The hypophyseal stalk (infundibulum) bridges the master endocrine gland to the ventral diencephalon of the brain.

Formula / Rule / Reaction:

Infundibulum = Neural stalk carrying hypothalamo-hypophyseal tracts + hypophyseal portal vasculature.

Solution:

- The infundibulum is a funnel-shaped stalk extending from the tuber cinereum of the hypothalamus.
- It suspends the pituitary gland (hypophysis cerebri) within the sella turcica of the sphenoid bone and transmits neurosecretory axons to the posterior pituitary.

Why other options are incorrect:

- **Option A:** The cerebellum is located in the posterior cranial fossa and is involved in motor coordination; it has no direct structural connection to the pituitary.
- **Option B:** The cerebrum forms the upper telencephalic hemispheres and does not directly anchor the pituitary stalk.
- **Option D:** The thalamus lies superior to the hypothalamus as a sensory relay center, but does not connect to the pituitary.

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

Both enzymes and coenzymes are:

CORE CONCEPT & DERIVATION

Catalytic molecules and their organic helper groups participate in reactions without being consumed or permanently altered in the process.

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

- Enzymes emerge chemically unaltered following the release of catalytic products.
- Similarly, coenzymes (such as NAD^+ or coenzyme A) undergo temporary chemical changes during catalysis, but are regenerated by coupled reactions and reused in multiple reaction cycles.

Why other options are incorrect:

- **Option A:** Enzymes are organic polypeptides and coenzymes are non-protein organic molecules; neither is inorganic.
- **Option C:** While many coenzymes are derived from water-soluble vitamins (e.g., niacin, riboflavin), enzymes themselves are encoded by genes and translated from amino acids.
- **Option D:** Enzymes are globular proteins, but coenzymes are non-protein low-molecular-weight organic compounds.

Question #55 Key: (D)BIOLOGY
01. Cell

Trans face of the Golgi complex is a:

CORE CONCEPT & DERIVATION

The Golgi apparatus has structural and functional polarity, consisting of a cis (forming) face and a trans (maturing) face.

Formula / Rule / Reaction:

Cis-face = Forming face (receives transport vesicles from ER) → Medial cisternae → Trans-face = Maturing face (buds secretory vesicles).

Solution:

- The cis face is the convex forming face where new cisternae are assembled by the fusion of endoplasmic reticulum transport vesicles.
- As cisternae mature through the stack via cisternal progression, they reach the concave trans face, known as the maturing face consisting of older cisternae that disintegrate into secretory vesicles.

Why other options are incorrect:

- **Option A:** The forming face is the cis face, not the trans face.
- **Option B:** The forming face is composed of newly arriving, young cisternae, not old cisternae.
- **Option C:** The maturing face is the trans face, but it consists of progressively older cisternae completing their processing cycle, not newly built ones.

Question #56 Key: (B)BIOLOGY
16. Evolution

Which type of organisms first evolved about 1.5 billion years ago?

CORE CONCEPT & DERIVATION

Geological and fossil records track the major evolutionary milestones of cellular life across Precambrian geological eras.

Formula / Rule / Reaction:

Prokaryotes ≈ 3.5 – 3.8 billion years ago → Eukaryotes ≈ 1.5 – 1.8 billion years ago → Multicellular animals ≈ 600 million years ago → Seed plants ≈ 360 million years ago.

Solution:

- Microfossil evidence and molecular clocks place the origin of single-celled eukaryotic organisms (such as acritarchs) at approximately 1.5 to 1.8 billion years ago (Proterozoic Eon).
- This evolutionary leap was mediated by endosymbiotic events that gave rise to mitochondria and plastids.

Why other options are incorrect:

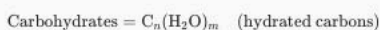
- **Option A:** Prokaryotes appeared much earlier, approximately 3.5 to 3.8 billion years ago in the Archean Eon.
- **Option C:** Complex multicellular animals first arose roughly 600 million years ago during the late Ediacaran period.
- **Option D:** Seed plants evolved during the late Devonian period, roughly 360 to 380 million years ago.

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

Which of the following statement is NOT true about proteins?

CORE CONCEPT & DERIVATION

Proteins are nitrogenous polymers of L-amino acids linked by peptide bonds, whereas hydrated carbons refers to carbohydrates.

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

- The term hydrated carbon historically designates carbohydrates, which follow the general empirical formula $\text{C}_x(\text{H}_2\text{O})_y$.
- Proteins contain carbon, hydrogen, oxygen, nitrogen, and frequently sulfur, and are not hydrates of carbon.

Why other options are incorrect:

- **Option A:** Proteins universally contain nitrogen (roughly 16% by mass) in their amino groups and peptide bonds.
- **Option B:** Structural proteins (such as collagen, actin, myosin, and keratin) constitute the primary architectural framework of tissues.
- **Option D:** Proteins are unbranched polymers synthesized from 20 standard amino acid monomers.

Question #58 Key: (C)BIOLOGY
03. Enzymes

Trace amounts of vitamins function in the body primarily as:

CORE CONCEPT & DERIVATION

Water-soluble vitamins undergo cellular phosphorylation or conjugation to act as essential organic cofactors (coenzymes) for metabolic enzymes.

Formula / Rule / Reaction:

Apoenzyme (inactive protein) + Coenzyme (vitamin derivative) → Holoenzyme (active catalyst).

Solution:

- Vitamins are micronutrients required in trace quantities because, like catalysts, their coenzyme forms are recycled repeatedly.
- For example, thiamine forms TPP, riboflavin forms FMN/FAD, niacin forms $\text{NAD}^+/\text{NADP}^+$, and pantothenic acid forms Coenzyme A.

Why other options are incorrect:

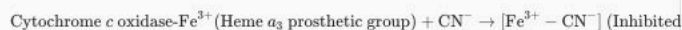
- **Option A:** Structural components of cells and tissues are provided by proteins, phospholipids, and minerals like calcium, not vitamins.
- **Option B:** Although Vitamin D behaves like a prohormone, the vast majority of vitamins in trace amounts function enzymatically as coenzymes.
- **Option D:** Vitamins yield zero direct metabolic energy (0 kcal/g); energy is derived from the catabolism of carbohydrates, fats, and proteins.

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

Cyanides block the action of enzymes by combining with:

CORE CONCEPT & DERIVATION

Cyanide (CN^-) is a potent enzyme inhibitor that forms a stable coordinate covalent complex with transition metal ions residing in prosthetic groups.

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

- Cyanide binds to the ferric iron (Fe^{3+}) located within the heme a_3 prosthetic group of cytochrome c oxidase (Complex IV).
- This halts the terminal step of the electron transport chain, blocking cellular respiration.

Why other options are incorrect:

- **Option B:** Coenzymes are dissociable organic cosubstrates (like NAD^+); cyanide does not exert its primary toxic action by binding free coenzymes.
- **Option C:** While a prosthetic group is a tightly bound cofactor, provincial textbook questions explicitly classify the heme iron target as the enzyme's permanent prosthetic group.
- **Option D:** Activators are inorganic metal ions or small molecules that enhance catalytic activity, not the targets through which cyanide poisons enzymes.

Question #60 Key: (B)BIOLOGY
12. Nervous Coordination

Action potential in the neuronal membrane starts the process of?

CORE CONCEPT & DERIVATION

When a neuron is stimulated past its threshold potential, voltage-gated sodium channels open rapidly, initiating an action potential via depolarization.

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

- An action potential begins with the opening of activation gates of voltage-gated Na^+ channels.
- The influx of positive sodium ions down their electrochemical gradient abolishes and reverses the resting negative internal polarity, starting depolarization.

Why other options are incorrect:

- **Option A:** Polarization describes the steady resting membrane state maintained by the Na^+/K^+ ATPase pump (-70 mV).
- **Option C:** Repolarization is the subsequent recovery phase driven by the delayed opening of voltage-gated K^+ channels.
- **Option D:** Hyperpolarization is the transient undershoot phase where membrane potential becomes more negative than the resting potential due to continued potassium efflux.

Question #61 Key: (B)BIOLOGY
07. Circulation / Transport

The maximum water potential of pure water is:

CORE CONCEPT & DERIVATION

Water potential (Ψ_w) measures the free energy of water molecules per unit volume relative to pure water at standard temperature and atmospheric pressure.

Formula / Rule / Reaction:

$$\Psi_w = \Psi_s + \Psi_p$$

For pure water at 1 atm and 25°C : $\Psi_w = 0$ MPa

Solution:

- Pure water possesses the highest possible concentration and kinetic energy of water molecules, with zero dissolved solutes.
- By international thermodynamic convention, its water potential is defined as zero.
- Adding solutes lowers the free energy, making solute potential and water potential negative.

Why other options are incorrect:

- **Option A:** -100 is an arbitrary negative value; water potential of solutions becomes negative, but the maximum baseline is 0.
- **Option C:** Water potential values do not have a baseline of +1 in open solutions under standard conditions.
- **Option D:** 100 represents a positive pressure potential under artificial compression, but pure water at atmospheric pressure has $\Psi_w = 0$.

Question #62 Key: (C)BIOLOGY
06. Digestion/Nutrition

Fasciola, an endoparasite in sheep, is mostly found in:

CORE CONCEPT & DERIVATION

Fasciola hepatica (common liver fluke) is a parasitic trematode that targets the hepatobiliary system of ruminants.

Formula / Rule / Reaction:

Metacercaria ingested by sheep → Excystation in duodenum → Penetration of gut wall and liver capsule → Adult resides in Bile ducts.

Solution:

- Adult flukes reside within the bile ducts and gallbladder of sheep, goats, and cattle.
- Their feeding activity and spines irritate the ductal epithelium, causing liver rot, fibrosis, and biliary obstruction.

Why other options are incorrect:

- **Option A:** Blood flukes belonging to the genus *Schistosoma* inhabit mesenteric and pelvic venous plexuses, not *Fasciola*.
- **Option B:** The large intestine is the habitat of certain nematodes (such as *Trichuris* or *Oesophagostomum*), not liver flukes.
- **Option D:** The stomach (abomasum/rumen) is inhabited by parasites like *Haemonchus contortus* and paramphistomes, not adult *Fasciola*.

Question #63 Key: (B)BIOLOGY
04. Bioenergetics

In chlorophyll a, a [Formula] group is attached to which pyrrole ring?

CORE CONCEPT & DERIVATION

Chlorophyll contains a porphyrin head consisting of four interconnected pyrrole rings (I, II, III, IV) coordinating a central magnesium ion.

Formula / Rule / Reaction:

Pyrrole Ring II: Attached group is $-\text{CH}_3$ in Chlorophyll a, and $-\text{CHO}$ in Chlorophyll b.

Solution:

- According to standard biochemical numbering (Fischer structure of chlorophylls), carbon-7 of pyrrole ring II carries a methyl group ($-\text{CH}_3$) in chlorophyll a.
- In chlorophyll b, this exact methyl group on ring II is replaced by a formyl/aldehyde group ($-\text{CHO}$).
- (Note: While some official board answer keys mistakenly marked Option A (1st), authoritative provincial and national textbooks confirm the functional distinguishing group resides on the second pyrrole ring).

Why other options are incorrect:

- **Option A:** The 1st pyrrole ring possesses standard methyl and vinyl substituents common to both chlorophyll a and b.
- **Option C:** The 3rd pyrrole ring possesses a propionic acid esterified to the phytol chain (via an adjacent cyclopentanone ring V).
- **Option D:** The 4th pyrrole ring carries standard methyl and ethyl substituents identical across both major chlorophyll variants.

Question #64 Key: (B)BIOLOGY
01. Cell

Which of the following organelles contains circular DNA and small-sized ribosomes?

CORE CONCEPT & DERIVATION

The endosymbiotic theory demonstrates that mitochondria and chloroplasts originated from ancestral prokaryotes engulfed by primitive eukaryotes.

Formula / Rule / Reaction:

Semiautonomous organelle features: Closed circular dsDNA (mtDNA) + 70S prokaryotic-like ribosomes.

Solution:

- Mitochondria possess their own independent genetic system consisting of double-stranded circular DNA localized in the matrix.
- They also contain small 70S (or 55S in mammalian mitochondrial ribosomes) ribosomes that perform organellar translation.

Why other options are incorrect:

- **Option A:** The nucleus contains linear chromosomes associated with basic histone proteins, and eukaryotic cytoplasm houses 80S ribosomes.
- **Option C:** The Golgi complex has no internal genome and contains no ribosomes.
- **Option D:** The endoplasmic reticulum membrane can bind 80S ribosomes (rough ER), but lacks internal circular DNA.

Question #65 Key: (C)BIOLOGY
01. Cell

Which of the following transport processes require energy for the movement of material across t...

CORE CONCEPT & DERIVATION

Bulk transport processes require cellular energy derived from ATP hydrolysis to rearrange the actin cytoskeleton and plasma membrane.

Formula / Rule / Reaction:

Active / Bulk transport: Vesicle formation + Cytoskeletal rearrangement $\propto$ ATP consumption.

Solution:

- Endocytosis (including phagocytosis and pinocytosis) involves membrane invagination, vesicle budding, and motor protein activity.
- Because this work is driven by ATP hydrolysis, it is an active, energy-dependent process.

Why other options are incorrect:

- **Option A:** Osmosis is the passive diffusion of solvent (water) molecules down a chemical potential gradient, requiring zero metabolic energy.
- **Option B:** Simple diffusion is a passive physical process driven entirely by the intrinsic kinetic thermal energy of solute particles.
- **Option D:** Facilitated diffusion relies on transmembrane channel or carrier proteins to move solutes down their electrochemical gradient without consuming ATP.

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

The mode of inheritance in humans can be traced through:

CORE CONCEPT & DERIVATION

Because controlled experimental breeding cannot be performed in human genetics, inherited traits and genetic disorders are investigated using family history records.

Formula / Rule / Reaction:

Pedigree chart symbols: Squares = Males, Circles = Females, Shaded = Affected phenotypes across generations.

Solution:

- Pedigree analysis tracks the transmission of specific phenotypic traits across multiple generations of an extended family.
- It allows geneticists to deduce whether a trait is autosomal dominant, autosomal recessive, X-linked, or mitochondrial.

Why other options are incorrect:

- **Option A:** Experimental mating is unethical and impossible in human populations, though standard for model organisms like *Drosophila*.
- **Option B:** A chi-square chart is a statistical tool used to test goodness-of-fit between observed and expected numerical frequencies, not a genealogical tracing tool.
- **Option D:** Probability analysis calculates theoretical risks, but cannot map ancestral inheritance patterns without an underlying pedigree.

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

Animals having jointed legs and a chitinous exoskeleton are known as:

CORE CONCEPT & DERIVATION

Phylum Arthropoda is distinguished by metameric segmentation, paired jointed appendages, and an impermeable cuticular exoskeleton.

Formula / Rule / Reaction:

Diagnostic arthropod characters = Jointed appendages (arthro + poda) + Chitinous cuticle + Tagmatization.

Solution:

- The name Arthropoda translates directly to 'jointed feet'.
- All members (insects, crustaceans, arachnids, and myriapods) secrete an exoskeleton made of a fibrous polysaccharide called chitin cross-linked with sclerotin proteins.

Why other options are incorrect:

- **Option A:** Chordates possess a notochord, a dorsal hollow nerve cord, pharyngeal gill slits, and an endoskeleton made of bone or cartilage.
- **Option C:** Annelids are metamerically segmented worms with a hydrostatic skeleton and a thin collagenous cuticle, lacking jointed legs.
- **Option D:** Molluscs are soft-bodied, unsegmented animals typically enclosed within a calcareous (CaCO_3) shell, lacking jointed appendages.

Question #68 Key: (B)BIOLOGY
01. Cell

Passage of water across a selectively permeable membrane is called:

CORE CONCEPT & DERIVATION

Osmosis is the specialized passive diffusion of water molecules across a semipermeable membrane from an area of higher water potential to lower water potential.

Formula / Rule / Reaction:

$$\text{Net water flux} \propto \Delta\Psi_w = (\Psi_{w,\text{inside}} - \Psi_{w,\text{outside}})$$

Solution:

- When two solutions of differing solute concentrations are separated by a membrane permeable to water but impermeable to solutes, water moves passively across.
- This specific physical transport process is defined as osmosis.

Why other options are incorrect:

- **Option A:** Active transport moves solute molecules against their concentration gradient via protein pumps coupled to ATP hydrolysis.
- **Option C:** Pinocytosis is the active, non-specific uptake of extracellular fluid droplets via membrane endocytic vesicles.
- **Option D:** Facilitated diffusion involves passive transport of solutes (such as glucose or amino acids) across membranes via carrier or channel proteins.

Question #69 Key: (B)

CHEMISTRY
06. Solids

The system in which three angles and axes are unequal is called?

CORE CONCEPT & DERIVATION

Crystals are classified into seven crystal systems based on the relative lengths of their unit cell edges and the angles between their faces.

Formula / Rule / Reaction:

Triclinic System: $a \neq b \neq c$ and $\alpha \neq \beta \neq \gamma \neq 90^\circ$

Solution:

- In the triclinic crystal system, all three crystallographic axes are unequal in length ($a \neq b \neq c$).
- Furthermore, all three interaxial angles are unequal to one another and none equals 90° , representing the lowest symmetry among the seven crystal classes (examples: $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, $\text{K}_2\text{Cr}_2\text{O}_7$).

Why other options are incorrect:

- Option A:** The cubic system possesses highest symmetry with three equal axes and three right angles ($a = b = c$, $\alpha = \beta = \gamma = 90^\circ$).
- Option C:** The orthorhombic system has three unequal axes, but all three angles are equal to 90° ($a \neq b \neq c$, $\alpha = \beta = \gamma = 90^\circ$).
- Option D:** The trigonal (rhombohedral) system has three equal axes and equal non-right angles ($a = b = c$, $\alpha = \beta = \gamma \neq 90^\circ$).

Question #70 Key: (D)

CHEMISTRY
01. Stoichiometry

Which one is incorrect for actual yield being less than theoretical yield?

CORE CONCEPT & DERIVATION

The actual yield of a chemical reaction is almost universally lower than the stoichiometrically calculated theoretical yield due to side reactions, equilibrium limitations, and experimental losses.

Formula / Rule / Reaction:

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

Solution:

- If starting materials and products are pure, unwanted side reactions are minimized and stoichiometry is maximized.
- Purity of a substance tends to increase the yield closer to theoretical values rather than decreasing it.
- Therefore, 'substance is pure' is an invalid reason for actual yield falling below theoretical yield.

Why other options are incorrect:

- Option A:** Mechanical losses during experimental manipulation (filtration, crystallization, transferring, washing) reduce actual recovered product.
- Option B:** Chemical equilibrium in reversible reactions prevents reactants from converting 100% into products.
- Option C:** Sub-threshold molecular kinetic energy limits conversion rates and completeness during finite reaction times.

Question #71 Key: (B)

CHEMISTRY
03. Chemical Bonding

Which of the following is the carbon atom of a carbonyl group?

CORE CONCEPT & DERIVATION

The hybridization of an atom is dictated by its steric number (sum of bonded atoms and non-bonding electron lone pairs).

Formula / Rule / Reaction:

Carbonyl carbon: $3 \sigma\text{-bonds} + 0 \text{ lone pairs} = \text{Steric Number } 3 \Rightarrow sp^2 \text{ hybridization}$

Solution:

- In a carbonyl group ($> \text{C} = \text{O}$), the carbon forms three coplanar σ -bonds (two to adjacent groups and one to oxygen) using sp^2 hybrid orbitals.
- The remaining unhybridized $2p_z$ orbital on carbon overlaps laterally with an unhybridized $2p_z$ orbital on oxygen to form a localized π -bond, producing a trigonal planar geometry with $\approx 120^\circ$ bond angles.

Why other options are incorrect:

- Option A:** An sp hybridized carbon forms two σ -bonds and two π -bonds with linear geometry (e.g., alkynes, nitriles, CO_2).
- Option C:** An sp^3 hybridized carbon forms four σ -bonds in a tetrahedral arrangement (e.g., alkanes, alcohols).
- Option D:** dsp^2 hybridization occurs in transition metal square planar coordination complexes, not in second-period main group elements like carbon.

Question #72 Key: (B)

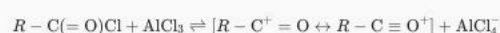
CHEMISTRY
14. Hydrocarbons

The acylium ion has a positive charge and acts as:

CORE CONCEPT & DERIVATION

An electrophile is an electron-deficient species capable of accepting an electron pair from a nucleophile to form a covalent chemical bond.

Formula / Rule / Reaction:



Solution:

- The acylium ion ($R - \text{C}^+ = \text{O}$) carries a formal positive charge and possesses an electron-deficient acyl carbon center.
- In electrophilic aromatic substitution (Friedel-Crafts acylation), it serves as the attacking electrophile targeted by the electron-rich aromatic π -system.

Why other options are incorrect:

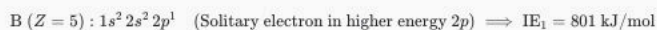
- Option A:** Nucleophiles are electron-rich species possessing non-bonding lone pairs or electron-dense π -bonds that donate electrons to electrophiles.
- Option C:** While structurally related to carbocations, the resonance-stabilized acylium cation is primarily functionalized and classified as an attacking electrophile in reaction mechanisms.
- Option D:** A carbanion is a trivalent carbon species bearing a negative formal charge and an unshared electron pair.

Question #73 Key: (C)CHEMISTRY
03. Chemical Bonding

Why is the first ionization energy of Beryllium higher than Boron?

CORE CONCEPT & DERIVATION

Filled and half-filled subshells possess exchange energy and symmetrical electron distributions that confer enhanced thermodynamic stability against ionization.

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

- Ionizing Beryllium requires removing an electron from a fully paired, stable $2s$ orbital possessing high penetration near the nucleus.
- Ionizing Boron involves removing an electron from a higher-energy $2p$ orbital that is well-shielded by the inner $1s^2 2s^2$ core.
- Hence, Beryllium requires greater energy to ionize.

Why other options are incorrect:

- **Option A:** Having a higher configuration is a meaningless colloquialism that fails to explain orbital stabilization energies.
- **Option B:** Atomic radius generally decreases across a period; Beryllium (112 pm) is actually slightly larger than Boron (85 pm), which would normally lower ionization energy if not for subshell stability.
- **Option D:** Boron has atomic number $Z = 5$, which is greater than Beryllium ($Z = 4$), not smaller.

Question #74 Key: (C)CHEMISTRY
06. Solids

Which one of the following has no cleavage plane?

CORE CONCEPT & DERIVATION

Cleavage planes occur in crystalline solids along flat planes of weak chemical bonding. Metallic crystals feature non-directional metallic bonding and undergo plastic deformation without cleaving.

Formula / Rule / Reaction:

Cleavage: Breakage along specific crystallographic planes where bonding is weakest. Metals deform plastically by dislocation slip.

Solution:

- Copper is a metallic crystal consisting of positive copper ions immersed in a delocalized sea of valence electrons.
- Because metallic bonds are non-directional, applied shear stress causes atom planes to slide past one another (malleability and ductility) rather than splitting along sharp cleavage planes.

Why other options are incorrect:

- **Option A:** Graphite cleaves readily along basal planes parallel to its carbon layers because layers are held together only by weak London dispersion forces.
- **Option B:** NaCl possesses sharp cubic cleavage along $\{100\}$ planes where like-charged ions align and repel upon stress.
- **Option D:** Ice crystals display distinct basal cleavage planes governed by structured hydrogen-bonded hexagonal networks.

Question #75 Key: (D)CHEMISTRY
11. S & P Block Elements

Which of the following metals does not react with water?

CORE CONCEPT & DERIVATION

Reactivity of alkaline earth metals with water increases down Group IIA as ionization energy decreases and atomic radius increases.

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

- Beryllium has high ionization energy and small atomic size, forming a protective, impervious oxide film (BeO) on its surface.
- Consequently, Beryllium does not react with liquid water or steam, even at red heat.

Why other options are incorrect:

- **Option A:** Magnesium reacts very slowly with hot water and burns vigorously in steam to yield magnesium oxide and hydrogen gas.
- **Option B:** Calcium reacts readily with cold liquid water to evolve hydrogen gas and form a cloudy suspension of calcium hydroxide.
- **Option C:** Sodium is an alkali metal that reacts explosively with cold water to generate sodium hydroxide and hydrogen gas.

Question #76 Key: (B)CHEMISTRY
04. Gases

A set of postulates that explain the behavior of an ideal gas is called:

CORE CONCEPT & DERIVATION

The Kinetic Molecular Theory (KMT) describes the macroscopic properties of gases by modeling them as submicroscopic point particles in continuous random motion.

Formula / Rule / Reaction:

$$PV = \frac{1}{3}mN\overline{c^2} = \frac{2}{3}E_k$$

Solution:

- Formulated by Bernoulli, Clausius, Maxwell, and Boltzmann, KMT presents the foundational postulates for ideal gases.
- Core assumptions state that gas molecules have negligible volume, exert no intermolecular forces, and undergo perfectly elastic collisions.

Why other options are incorrect:

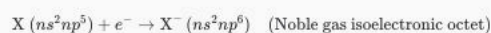
- **Option A:** Bohr's theory describes quantized electronic orbits and emission spectra of hydrogen-like atoms.
- **Option C:** Rutherford's nuclear theory demonstrated that the positive charge and mass of an atom reside in a dense central nucleus.
- **Option D:** Dalton's atomic theory established that matter is composed of indivisible atoms and formulated laws of chemical stoichiometry.

Question #77 Key: (B)CHEMISTRY
11. S & P Block Elements

The general electronic configuration of halide ions is:

CORE CONCEPT & DERIVATION

Halogen atoms (Group VIIA) require one additional valence electron to achieve a noble-gas octet configuration, forming univalent halide anions.

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

- Neutral halogens possess a valence configuration of ns^2np^5 with seven valence electrons.
- When reduced by gaining an electron, the resulting halide ion (F^- , Cl^- , Br^- , I^-) fills its valence shell to achieve the stable octet ns^2np^6 .

Why other options are incorrect:

- Option A:** ns^2np^5 is the ground-state valence configuration of a neutral halogen atom, not a halide anion.
- Option C:** ns^1np^5 represents an excited electronic state of a neutral group 16/chalcogen atom.
- Option D:** ns^2np^3 is the valence shell configuration of neutral Group VA pnictogen elements (e.g., Nitrogen, Phosphorus).

Question #78 Key: (B)CHEMISTRY
09. Thermochemistry

Thermodynamically, the most stable form of carbon is:

CORE CONCEPT & DERIVATION

The standard thermodynamic state of an element is its most stable physical allotrope at 298.15 K and 1 atm, defined by having the lowest Gibbs free energy of formation.

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

- Graphite has a lower standard molar Gibbs free energy than diamond, fullerene, or amorphous carbon.
- By thermochemical convention, the standard enthalpy of formation (ΔH_f°) of graphite is assigned exactly 0 kJ/mol, making it the thermodynamically most stable allotrope.

Why other options are incorrect:

- Option A:** Diamond is kinetically stable (metastable) due to huge activation barriers, but thermodynamically less stable than graphite by 2.9 kJ/mol.
- Option C:** Peat is a heterogeneous, impure precursor mixture of decaying vegetable matter, not an elemental allotrope of carbon.
- Option D:** Coal is a sedimentary rock containing impure amorphous carbon mixed with volatile hydrocarbons and minerals.

Question #79 Key: (A)CHEMISTRY
19. Macromolecules / Biochemistry

Protein content of human milk is about

CORE CONCEPT & DERIVATION

Human breast milk is biochemically adapted for infant digestion, possessing a lower total protein concentration than bovine milk.

Formula / Rule / Reaction:Macronutrient composition of mature human milk: $\approx$ 87% Water, 7% Lactose, 4% Fat, and 1.1 – 1.4% Protein.**Solution:**

- Mature human milk contains approximately 1.1 to 1.4 g of protein per 100 mL (roughly 1.4%).
- This low protein content protects immature neonatal kidneys from excessive solute and urea load while providing whey-dominant immunoglobulins and lactoferrin.

Why other options are incorrect:

- Option B:** 2.4% is significantly higher than physiological levels in mature human milk.
- Option C:** 3.4% represents the average protein concentration found in cow's milk (bovine milk), which contains high amounts of casein.
- Option D:** 4.4% exceeds the physiological protein concentrations of both human and bovine dairy milks.

Question #80 Key: (B)CHEMISTRY
17. Aldehydes & Ketones

In base-catalyzed nucleophilic addition reactions of aldehydes and ketones, the base reagent ac...

CORE CONCEPT & DERIVATION

Base catalysts accelerate nucleophilic additions to carbonyl compounds by deprotonating weak pro-nucleophiles into potent, negatively charged nucleophiles.

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

- In reactions such as aldol condensation or cyanohydrin formation, a base catalyst extracts a proton from the reagent (e.g., $\text{HCN} + \text{OH}^- \rightarrow \text{H}_2\text{O} + \text{CN}^-$).
- This generates a powerful nucleophile capable of rapidly attacking the carbonyl carbon.

Why other options are incorrect:

- Option A:** Amphoteric refers to substances that can react as both acids and bases (e.g., water, amino acids), not the functional attacking intermediate.
- Option C:** Electrophobic is a non-standard, fictitious chemical term.
- Option D:** Acid catalysts (not base catalysts) act by protonating the carbonyl oxygen to increase the electrophilicity of the carbonyl carbon.

Question #81 Key: (B)

CHEMISTRY
12. Transition Elements

Which of the following is a bidentate ligand?

CORE CONCEPT & DERIVATION

Ligands are categorized by their denticity (the number of donor atoms through which they coordinate to a central metal cation).

Formula / Rule / Reaction:

Hydrazine: $\text{H}_2\ddot{\text{N}}-\ddot{\text{N}}\text{H}_2$ (Two basic nitrogen donor centers with lone pairs)

Solution:

- Hydrazine (N_2H_4) contains two adjacent nitrogen atoms, each possessing a non-bonding electron pair capable of simultaneous or bridging coordination.
- Consequently, it functions as a bidentate (or bridging bidentate) ligand.

Why other options are incorrect:

- Option A:** Ammine ($:\text{NH}_3$) has a single nitrogen lone pair, making it a classic monodentate ligand.
- Option C:** Aqua ($\text{H}_2\text{O}:$) coordinates through only one lone pair on its oxygen atom, acting as a monodentate ligand.
- Option D:** Carbonyl ($:\text{CO}$) coordinates through its carbon atom, acting as a monodentate ligand.

Question #82 Key: (A)

CHEMISTRY
14. Hydrocarbons

What do we mean by the term "delocalized electrons" in benzene?

CORE CONCEPT & DERIVATION

The six $2p_z$ unhybridized atomic orbitals in benzene overlap sideways continuously around the cyclic hexagonal ring, generating completely delocalized molecular orbitals.

Formula / Rule / Reaction:

Benzene: 6π electrons delocalized in continuous tori (doughnuts) of electron density above and below the planar carbon ring.

Solution:

- Benzene's six carbon atoms are sp^2 hybridized and lie in a single plane.
- Their perpendicular unhybridized p orbitals merge to form a cyclic π -system containing six delocalized electrons that circulate freely above and below the nuclear plane.

Why other options are incorrect:

- Option B:** Delocalized electrons are explicitly free to move; stating they are 'not free' contradicts the definition of delocalization.
- Option C:** The σ -bonding framework in benzene consists of localized two-center two-electron bonds lying within the molecular plane.
- Option D:** While partially correct, it omits the vital geometric detail that the cyclic π -system forms lobes specifically above and below the carbon ring plane.

Question #83 Key: (D)

CHEMISTRY
03. Chemical Bonding

Which of the following pairs is isostructural?

CORE CONCEPT & DERIVATION

Chemical species are isostructural when they possess identical three-dimensional molecular geometries and central atom hybridizations.

Formula / Rule / Reaction:

VSEPR formula for both SO_3 and $\text{BF}_3 = \text{AX}_3$ (Zero lone pairs on central atom)Geometry = Trigonal Planar (120° bond angles, sp^2 hybridization)

Solution:

- In SO_3 , sulfur has 6 valence electrons and forms three double bonds with three oxygen atoms (sp^2 , trigonal planar).
- In BF_3 , boron has 3 valence electrons and forms three single bonds with three fluorines (sp^2 , trigonal planar).
- Both lack lone pairs on the central atom and are isostructural.

Why other options are incorrect:

- Option A:** AlCl_3 is trigonal planar (monomeric gas phase) while CH_4 is tetrahedral (sp^3).
- Option B:** BF_3 is trigonal planar, whereas NH_3 has a central lone pair and is trigonal pyramidal.
- Option C:** SnCl_2 has a lone pair and is bent/V-shaped, whereas BeCl_2 is linear (sp).

Question #84 Key: (B)

CHEMISTRY
18. Carboxylic Acids

Acetic acid is a weaker acid than sulfuric acid because of which of the following reasons?

CORE CONCEPT & DERIVATION

Acid strength is governed by the equilibrium position and degree of protolytic dissociation (α) in aqueous solution.

Formula / Rule / Reaction:



Solution:

- Sulfuric acid is a mineral strong acid that ionizes completely into hydronium and bisulfate ions in dilute water solutions.
- Acetic acid is a weak organic carboxylic acid that undergoes very partial ionization (roughly 1% in 0.1 M solution), leaving mostly un-ionized molecules.

Why other options are incorrect:

- Option A:** Thermal decomposition characteristics do not dictate aqueous acid dissociation equilibrium constants under standard conditions.
- Option C:** Possessing a $-\text{COOH}$ group makes it a carboxylic acid, but does not explain why it is weaker than H_2SO_4 .
- Option D:** The methyl group has an electron-donating $+I$ inductive effect that destabilizes the carboxylate anion, but acid strength is fundamentally quantified by the degree of ionization.

Question #85 Key: (C)CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Number of primary carbon atoms present in isobutane

CORE CONCEPT & DERIVATIONCarbon atoms are classified by their degree of substitution: a primary (1°) carbon is directly bonded to only one other carbon atom.**Formula / Rule / Reaction:****Solution:**

- Isobutane (2-methylpropane) consists of a central CH group attached to three peripheral $-\text{CH}_3$ methyl groups.
- Each of the three methyl carbons is directly bonded only to the central tertiary carbon, classifying all three as primary (1°) carbon atoms.
- The central carbon is bonded to three carbons, making it tertiary (3°).

Why other options are incorrect:

- Option A:** One primary carbon is found in species like chloromethane or methanol, not isobutane.
- Option B:** Two primary carbons are found in linear alkanes like propane ($\text{CH}_3 - \text{CH}_2 - \text{CH}_3$) or n-butane.
- Option D:** Neopentane (2,2-dimethylpropane) possesses four primary carbons; isobutane has only four total carbons, one of which is tertiary.

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

In which method can the rate of reaction involving ions be studied

CORE CONCEPT & DERIVATION

Physical methods for monitoring reaction kinetics rely on measuring changes in a physical property that is directly proportional to reactant or product concentration.

Formula / Rule / Reaction:

$$\kappa = \sum c_i \lambda_i \quad (\text{Conductivity is directly proportional to ion concentrations and their molar ionic conductivities})$$

Solution:

- When a chemical reaction results in a net change in the concentration or mobility of ions in solution, electrical conductance changes over time.
- Conductometric analysis (electrical conductivity method) monitors this rate of change without perturbing the reaction mixture.

Why other options are incorrect:

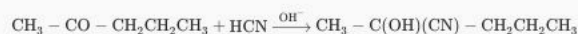
- Option B:** The optical rotation method (polarimetry) is used specifically for reactions involving optically active chiral molecules (e.g., inversion of cane sugar).
- Option C:** Refractometry tracks changes in the refractive index of homogeneous liquid mixtures.
- Option D:** Spectrometry monitors absorbance or transmittance of light by colored substances or UV-active chromophores, not general ionic charges.

Question #87 Key: (B)CHEMISTRY
17. Aldehydes & Ketones

What occurs when carbonyl compounds react with HCN

CORE CONCEPT & DERIVATION

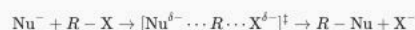
Nucleophilic addition of hydrogen cyanide to asymmetric ketones generates cyanohydrins containing a newly formed stereocenter (asymmetric carbon).

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

- The addition of cyanide to the planar carbonyl group of pentan-2-one produces 2-hydroxy-2-methylpentanenitrile.
- The central carbon atom (C-2) becomes bonded to four distinctly different groups: $-\text{CH}_3$, $-\text{OH}$, $-\text{CN}$, and $-\text{CH}_2\text{CH}_2\text{CH}_3$.
- Because it possesses an asymmetric carbon center, the product is chiral.

Why other options are incorrect:

- Option A:** Cyanohydrin formation is base-catalyzed (generates the nucleophilic CN^-); strong acids like concentrated H_2SO_4 suppress HCN ionization.
- Option C:** The reaction is an addition reaction (no small molecule like water is eliminated); it is not a condensation reaction.
- Option D:** Carbonyl addition reactions are nucleophilic additions across the $\text{C} = \text{O}$ double bond, not nucleophilic substitutions.

Question #88 Key: (D)CHEMISTRY
17. Aldehydes & KetonesThe overall charge on the transition state in an $\text{S}_\text{N}2$ reaction is?**CORE CONCEPT & DERIVATION**In an $\text{S}_\text{N}2$ mechanism involving an anionic nucleophile and a neutral alkyl halide, bond-making and bond-breaking occur concertedly via a pentacoordinate transition state.**Formula / Rule / Reaction:****Solution:**

- As the incoming nucleophile approaches, it donates electron density to the central carbon while the leaving group withdraws electron density.
- The formal negative charge is dispersed across both the nucleophile and leaving group, making the peripheral reacting centers partially negative (δ^-).

Why other options are incorrect:

- Option A:** While the total net charge is -1 , the transition state itself features dispersed, partial negative charges at the reacting bonds.
- Option B:** The transition state does not develop a positive charge because an electron-rich nucleophile is attacking.
- Option C:** The overall system carries negative charge from the attacking nucleophile, so it is not electrically neutral.

Question #89 Key: (C)

CHEMISTRY
11. S & P Block Elements

Which ionic radius is the smallest?

CORE CONCEPT & DERIVATION

In an isoelectronic series, ionic radius decreases systematically as nuclear charge (atomic number Z) increases.

Formula / Rule / Reaction:

Isoelectronic series (10 electrons): $\text{Na}^+(Z=11) > \text{Mg}^{2+}(Z=12) > \text{Al}^{3+}(Z=13)$

Solution:

- Na^+ , Mg^{2+} , and Al^{3+} all have the neon core configuration (10 electrons: $1s^2 2s^2 2p^6$).
- Al^{3+} possesses 13 protons pulling on these 10 electrons, giving it the highest effective nuclear charge and pulling the electron cloud in closest (ionic radius ≈ 54 pm).

Why other options are incorrect:

- **Option A:** Na^+ has only 11 protons to attract 10 electrons, resulting in a larger radius (≈ 102 pm).
- **Option B:** Mg^{2+} has 12 protons, resulting in an intermediate radius (≈ 72 pm), larger than Al^{3+} .
- **Option D:** Mg^{2+} has 11 electrons and lower nuclear attraction per electron, making it larger than Mg^{2+} .

Question #90 Key: (C)

CHEMISTRY
02. Atomic StructureWhat is the quantum number for the unpaired electron of a chlorine atom (n, l, m)?

CORE CONCEPT & DERIVATION

Quantum numbers define the energy level (n), orbital angular momentum/subshell (l), and spatial orientation (m) of an electron.

Formula / Rule / Reaction:

 $\text{Cl} (Z=17) : 1s^2 2s^2 2p^6 3s^2 3p_x^2 3p_y^2 3p_z^1$

Solution:

- The unpaired electron in a ground-state chlorine atom resides in the $3p$ subshell.
- For a $3p$ orbital: principal quantum number $n = 3$, azimuthal quantum number $l = 1$, and magnetic quantum number $m \in \{-1, 0, +1\}$.
- Among the choices, $(3, 1, 1)$ is the valid set corresponding to the $3p$ orbital.

Why other options are incorrect:

- **Option A:** $(2, 1, 0)$ describes an electron in the fully filled $2p$ subshell of the second energy shell.
- **Option B:** $(2, 1, 1)$ describes an electron in the inner $2p$ subshell.
- **Option D:** $(3, 0, 0)$ describes an electron in the paired $3s$ orbital (since $l = 0$ corresponds to an s-orbital).

Question #91 Key: (A)

CHEMISTRY
12. Transition Elements

Group 1B is called the coinage metals. Which one is not true about this group?

CORE CONCEPT & DERIVATION

Coinage metals (Cu, Ag, Au) are chemically noble transition elements characterized by high ionization energies and positive standard reduction potentials.

Formula / Rule / Reaction:

 $E_{\text{red}}^\circ(\text{Cu}^{2+}/\text{Cu}) = +0.34 \text{ V}, \quad E_{\text{red}}^\circ(\text{Ag}^+/\text{Ag}) = +0.80 \text{ V}, \quad E_{\text{red}}^\circ(\text{Au}^{3+}/\text{Au}) = +1.50 \text{ V}$

Solution:

- Species with large positive standard reduction potentials have a high tendency to gain electrons (be reduced) and resist oxidation.
- Therefore, coinage metals are very weak reducing agents, making the claim that they are powerful reducing agents false.

Why other options are incorrect:

- **Option B:** All group 1B metals possess positive standard reduction potentials relative to the standard hydrogen electrode.
- **Option C:** Because their reduction potentials are higher than hydrogen ($E^\circ = 0.00 \text{ V}$), they cannot displace hydrogen gas from non-oxidizing dilute acids.
- **Option D:** In standard electrochemical series convention (written in order of increasing reduction potential), elements with positive potentials lie below the Standard Hydrogen Electrode (SHE).

Question #92 Key: (C)

CHEMISTRY
01. Stoichiometry

What is the weight of oxygen that required for the complete combustion of 3.2 kg of methane?

CORE CONCEPT & DERIVATION

Stoichiometry calculations use balanced chemical combustion equations to determine mass relationships between reactants and products.

Formula / Rule / Reaction:

 $\text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O}$ Molar mass of $\text{CH}_4 = 16.04 \text{ g/mol}$, Molar mass of $\text{O}_2 = 32.00 \text{ g/mol}$

Solution:

- 1 mole of CH_4 (16 g) requires 2 moles of O_2 ($2 \times 32 = 64 \text{ g}$).
- The mass ratio is: $\frac{\text{Mass of O}_2}{\text{Mass of CH}_4} = \frac{64 \text{ g}}{16 \text{ g}} = 4$.
- For 3.2 kg of methane: Mass of $\text{O}_2 = 3.2 \text{ kg} \times 4 = 12.8 \text{ kg}$.

Why other options are incorrect:

- **Option A:** 3.2 kg assumes a 1:1 mass ratio, ignoring the 1:2 stoichiometric mole ratio and oxygen's higher molar mass.
- **Option B:** 6.4 kg accounts for only 1 mole of O_2 per mole of methane rather than the required 2 moles.
- **Option D:** 15.4 kg is an overestimation arising from incorrect stoichiometry.

Question #93 Key: (D)

CHEMISTRY
01. Stoichiometry

How many moles of a gas occupy 30.57 L at 55°C and 0.83 atm?

CORE CONCEPT & DERIVATION

The ideal gas law relates pressure, volume, temperature, and quantity of an ideal gas.

Formula / Rule / Reaction:

$$PV = nRT \Rightarrow n = \frac{PV}{RT}$$

Solution:

- Convert temperature to Kelvin: $T = 55 + 273.15 = 328.15$ K.
- Substitute values: $P = 0.83$ atm, $V = 30.57$ L, and $R = 0.0821$ L · atm/(mol · K).

- Calculate moles:

$$n = \frac{0.83 \times 30.57}{0.0821 \times 328.15} = \frac{25.3731}{26.941} \approx 0.942 \text{ moles}$$

Why other options are incorrect:

- Option A:** 0.1 mol results from arithmetic scale errors.
- Option B:** 0.62 mol occurs if temperature is left in Celsius (55) rather than converted to absolute Kelvin.
- Option C:** 0.84 mol is a calculation error failing to account for the 55°C thermal expansion.

Question #94 Key: (C)

CHEMISTRY
02. Atomic Structure

Which statement about a 4d orbital is correct?

CORE CONCEPT & DERIVATION

A subshell with orbital angular momentum $l = 2$ consists of five degenerate d -orbitals, accommodating up to 10 electrons.

Formula / Rule / Reaction:

$$\text{Maximum electrons in a subshell} = 2(2l + 1)$$

$$\text{For } d\text{-subshell } (l = 2) : 2(2(2) + 1) = 2(5) = 10 \text{ electrons}$$

Solution:

- A d subshell consists of 5 spatial orbitals (d_{xy} , d_{yz} , d_{zx} , $d_{x^2-y^2}$, d_{z^2}).
- According to the Pauli exclusion principle, each orbital accommodates a maximum of two electrons of opposite spin, giving a capacity of 10 electrons.

Why other options are incorrect:

- Option A:** 4d orbitals have double-dumbbell or doughnut shapes, distinctly different from the single dumbbell shape of 4p orbitals.
- Option B:** Zinc ($Z = 30$) has the configuration $[\text{Ar}]3d^{10}4s^2$; its 4d subshell is completely vacant.
- Option D:** In the fourth principal shell ($n = 4$), the 4f subshell ($l = 3$) has a higher energy than the 4d subshell.

Question #95 Key: (C)

CHEMISTRY
09. Thermochemistry

Hess's law states the same thing as

CORE CONCEPT & DERIVATION

Hess's law of constant heat summation is a direct manifestation of the principle of conservation of energy applied to chemical reactions.

Formula / Rule / Reaction:

$$\Delta H_{\text{overall}} = \sum \Delta H_{\text{intermediate steps}}$$

$$\Delta U = q + w \quad (\text{First Law of Thermodynamics})$$

Solution:

- Enthalpy (H) is a state function, meaning its change depends solely on the initial and final thermodynamic states, not the pathway taken.
- If the enthalpy change varied depending on the reaction route, a cyclic process could generate or destroy energy, violating the First Law of Thermodynamics.

Why other options are incorrect:

- Option A:** Henry's law relates gas solubility in a liquid to the partial pressure of that gas above the liquid.
- Option B:** The second law of thermodynamics establishes that the total entropy of an isolated system always increases in spontaneous processes.
- Option D:** Second law of thermochemistry is not an established scientific law.

Question #96 Key: (D)

CHEMISTRY
02. Atomic Structure

Which of the following is not true about canal rays?

CORE CONCEPT & DERIVATION

Canal rays (positive rays) consist of streams of positively charged gaseous ions that carry momentum and kinetic energy.

Formula / Rule / Reaction:

$$p = mv \Rightarrow \text{Momentum transferred upon collision produces mechanical rotation of a light paddle wheel}$$

Solution:

- When canal rays strike a light paddle wheel placed in their path within a discharge tube, the wheel rotates.
- This proves canal ray particles possess mass and momentum, meaning the statement that they 'do not cause mechanical motion' is false.

Why other options are incorrect:

- Option A:** When hydrogen gas is used in the discharge tube, the positive ions are protons with a mass of 1.6726×10^{-27} kg.
- Option B:** The charge-to-mass ratio (e/m) of a proton in canal rays is $\frac{1.602 \times 10^{-19} \text{ C}}{1.6726 \times 10^{-27} \text{ kg}} = 9.58 \times 10^7 \text{ C/kg}$.
- Option C:** Canal rays are streams of positive ions and undergo deflection toward the negative plate in electric and magnetic fields.

Question #97 Key: (B)

CHEMISTRY
18. Carboxylic Acids

The solubility of carboxylic acid in water gradually decreases with:

CORE CONCEPT & DERIVATION

The solubility of organic molecules in polar water depends on the competitive balance between their hydrophilic polar groups and hydrophobic non-polar hydrocarbon chains.

Formula / Rule / Reaction:

Lower carboxylic acids ($C_1 - C_4$): Miscible in water via hydrogen bonding.
Higher carboxylic acids ($> C_5$): Insoluble due to bulky hydrophobic alkyl chains.

Solution:

- Carboxylic acids form hydrogen bonds with water molecules using their polar $-COOH$ group.
- As molecular mass increases, the non-polar hydrophobic hydrocarbon tail ($R-$) elongates, increasingly disrupting the water hydrogen-bonding network and reducing solubility.

Why other options are incorrect:

- Option A:** A decrease in molecular mass increases solubility; lower acids (formic, acetic) are completely miscible with water.
- Option C:** Increasing the amount of solute reaches the saturation point, but does not alter intrinsic solubility characteristics.
- Option D:** Decreasing water volume reduces the total dissolved mass capacity, but does not define the fundamental molecular solubility trend.

Question #98 Key: (C)

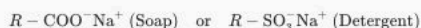
CHEMISTRY
05. Liquids

The polar part of soap and detergent dissolves in water molecules due to:

CORE CONCEPT & DERIVATION

Soaps and synthetic detergents are amphiphilic molecules possessing a long non-polar hydrophobic hydrocarbon tail and an ionic, highly polar hydrophilic head group.

Formula / Rule / Reaction:



Solution:

- The polar carboxylate ($-COO^-$) or sulfonate ($-SO_3^-$) head groups interact strongly with water molecules.
- They form strong hydrogen bonds and ion-dipole attractions with surrounding water dipoles, enabling the polar heads to dissolve in water.

Why other options are incorrect:

- Option A:** Dipole-dipole forces operate between neutral polar molecules, which are weaker than the dominant hydrogen-bonding and ion-dipole interactions here.
- Option B:** Dipole-induced dipole interactions occur between a polar molecule and a non-polar molecule (e.g., HCl and benzene).
- Option D:** London dispersion forces are weak non-polar intermolecular attractions that operate between the hydrocarbon tails within the micelle core.

Question #99 Key: (A)

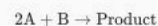
CHEMISTRY
01. Stoichiometry

When equal moles of reactants A and B are allowed to react according to the following balanced ...

CORE CONCEPT & DERIVATION

The limiting reactant is the chemical species that produces the smallest amount of product and is completely consumed first in a reaction.

Formula / Rule / Reaction:



Solution:

- The balanced stoichiometry requires 2 moles of reactant A for every 1 mole of reactant B.
- If starting with equal molar quantities (e.g., 1 mole of A and 1 mole of B), 1 mole of A can only react with 0.5 moles of B.
- Reactant A is completely consumed while 0.5 moles of B remains unreacted, making reactant A the limiting reactant.

Why other options are incorrect:

- Option B:** Reactant B is present in stoichiometric excess (only half of it is required).
- Option C:** Both reactants can only be limiting simultaneously if their initial amounts are in the exact stoichiometric ratio of 2:1.
- Option D:** A limiting reactant is always present when reactants are supplied in non-stoichiometric ratios.

Question #100 Key: (D)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

The hydrocarbon which has three linear fused benzene rings?

CORE CONCEPT & DERIVATION

Polycyclic aromatic hydrocarbons (PAHs) consist of fused benzene rings sharing common ortho-carbon bonds in either linear or angular configurations.

Formula / Rule / Reaction:

Anthracene: $C_{14}H_{10}$ (Three benzene rings fused in a straight, linear line)

Phenanthrene: $C_{14}H_{10}$ (Three benzene rings fused in an angular arrangement)

Solution:

- Anthracene consists of three benzene rings fused linearly side-by-side.
- This structure gives it distinct aromatic properties and characteristic chemical reactivity at its 9,10 positions.

Why other options are incorrect:

- Option A:** Phenanthrene is an isomer of anthracene that contains three fused benzene rings arranged in an angular (kinked) geometry.
- Option B:** Triphenylmethane consists of three independent phenyl rings bonded to a single central sp^3 carbon atom; they are not fused.
- Option C:** Diphenyl ether contains two isolated benzene rings linked by an oxygen atom bridge ($Ph - O - Ph$).

Question #101 Key: (B)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Which functional group is characteristic of an ester?

CORE CONCEPT & DERIVATION

Esters are carboxylic acid derivatives in which the hydroxyl (-OH) group of the carboxyl moiety is replaced by an alkoxy (-OR) or aryloxy (-OAr) group.

Formula / Rule / Reaction:

General formula of an ester: $R - C(=O) - O - R'$ (abbreviated as $R-CO-OR$)

Solution:

- An ester functional group consists of a carbonyl carbon bonded directly to an ether-like oxygen, which is in turn bonded to another alkyl or aryl radical.
- This structure is represented by the formula $R-CO-OR$.

Why other options are incorrect:

- Option A:** $R-CO-R$ is the general formula of a ketone.
- Option C:** $R-CO-OH$ is the general formula of a carboxylic acid.
- Option D:** $R-O-R$ is the general formula of an ether.

Question #102 Key: (C)

CHEMISTRY
18. Carboxylic Acids

Which of the following acids has the smallest dissociation constant?

CORE CONCEPT & DERIVATION

The acid dissociation constant (K_a) quantifies acid strength. A smaller K_a indicates a weaker acid, governed by the electronegativity and distance of electron-withdrawing substituents.

Formula / Rule / Reaction:

Electron-withdrawing inductive effect (-I effect): Decreases with increasing distance from the -COOH group, and decreases with lower halogen electronegativity ($F > Cl > Br > I$).

Solution:

- Bromine is less electronegative than fluorine, exerting a weaker electron-withdrawing -I effect.
- In 3-bromopropanoic acid ($BrCH_2CH_2COOH$), the bromine atom is located at the β -carbon, two carbon bonds away from the carboxylate center.
- The combined low electronegativity and greater distance provide the least conjugate base stabilization, resulting in the weakest acidity and smallest K_a .

Why other options are incorrect:

- Option A:** Fluorine is strongly electronegative and situated at the α -position, strongly stabilizing the conjugate base and increasing K_a .
- Option B:** Fluorine is far more electronegative than bromine, producing a stronger -I effect than β -bromine.
- Option D:** In 2-bromopropanoic acid, the bromine is on the α -carbon, exerting a stronger inductive effect than in the β -substituted isomer.

Question #103 Key: (D)

CHEMISTRY
05. Liquids

At atmospheric pressure, glycerin boils with decomposition at 290°C. What is the boiling point...

CORE CONCEPT & DERIVATION

The boiling point of a liquid drops when external ambient pressure is reduced. Vacuum distillation allows temperature-sensitive compounds to boil below their decomposition temperatures.

Formula / Rule / Reaction:

$$\ln\left(\frac{P_2}{P_1}\right) = -\frac{\Delta H_{\text{vap}}}{R} \left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

Solution:

- Glycerin (glycerol) decomposes chemically at its normal boiling point of 290°C at 760 torr.
- Reducing the external pressure to 50 torr lowers its boiling point to 210°C, enabling distillation without thermal degradation.

Why other options are incorrect:

- Option A:** 320°C exceeds the normal boiling point, which would require hyperbaric pressure (above 760 torr).
- Option B:** 310°C would require an external pressure greater than 1 atmosphere.
- Option C:** 300°C is higher than the standard boiling point, contrary to the effect of reduced pressure.

Question #104 Key: (A)

CHEMISTRY
07. EquilibriumThe solubility of $KClO_3$ is decreased by adding:

CORE CONCEPT & DERIVATION

The common ion effect states that the solubility of a sparingly soluble salt is reduced when a soluble salt sharing a common ion is introduced into the solution.

Formula / Rule / Reaction:



Solution:

- Dissolving KCl releases potassium ions (K^+) into the solution.
- According to Le Chatelier's principle, the elevated $[K^+]$ shifts the dissociation equilibrium to the left, causing $KClO_3$ to precipitate and lowering its solubility.

Why other options are incorrect:

- Option B:** Adding solid $KClO_3$ to a saturated solution does not alter the equilibrium concentration of dissolved ions.
- Option C:** Adding water dilutes the solution, allowing more solid solute to dissolve rather than decreasing solubility.
- Option D:** Solubility is directly affected by changes in common ion concentrations.

Question #105 Key: (B)

CHEMISTRY
19. Macromolecules / Biochemistry

For every reaction occurring in the human body, there is at least one type of:

CORE CONCEPT & DERIVATION

Biochemical reactions in living organisms require biological catalysts (enzymes) to proceed at physiological temperatures and neutral pH.

Formula / Rule / Reaction:



Solution:

- Virtually every biochemical pathway in cellular metabolism is catalyzed by a specific enzyme.
- Without these specialized catalysts, metabolic reactions would proceed too slowly to sustain life.

Why other options are incorrect:

- **Option A:** Vitamins serve as coenzyme precursors for specific classes of enzymes, but are not present in every single reaction.
- **Option C:** While most enzymes are proteins, the specific functional agent required for each reaction is defined by its catalytic enzyme identity.
- **Option D:** Free amino acids serve as metabolic intermediates and monomeric precursors, but do not directly catalyze individual metabolic steps.

Question #106 Key: (A)

CHEMISTRY
12. Transition Elements

Why do transition elements form alloys so easily?

CORE CONCEPT & DERIVATION

Substitutional alloys form when the atomic radii of the component elements differ by less than roughly 15%, as defined by the Hume-Rothery rules.

Formula / Rule / Reaction:

$$\% \text{ Difference in Atomic Radii} = \frac{|r_{\text{solute}} - r_{\text{solvent}}|}{r_{\text{solvent}}} \times 100 \leq 15\%$$

Solution:

- Transition metals in a given period have very similar atomic radii due to the shielding effect of inner $(n-1)d$ electrons.
- Because of this close match in atomic size, atoms of one transition metal can readily replace atoms of another within the crystal lattice, facilitating alloy formation.

Why other options are incorrect:

- **Option B:** Orbital configuration influences oxidation states and magnetism, but physical lattice substitution depends primarily on atomic size compatibility.
- **Option C:** Transition metals generally have high densities and are not light elements.
- **Option D:** Hardness is a bulk physical property that results from metallic bonding, not the primary geometric condition that permits lattice substitution.

Question #107 Key: (B)

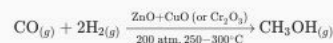
CHEMISTRY
16. Alcohols & Phenols

Methanol is prepared from carbon monoxide and hydrogen. The catalyst used for this reaction is:

CORE CONCEPT & DERIVATION

Industrial synthesis of methanol involves the catalytic hydrogenation of carbon monoxide (synthesis gas) over mixed transition metal oxide catalysts.

Formula / Rule / Reaction:



Solution:

- Modern industrial synthesis uses a catalyst containing zinc oxide and copper oxide (frequently augmented with chromium or aluminum oxides).
- This catalyst mixture provides high selectivity and activity at moderate temperatures and pressures. (Note: While historical processes used $\text{ZnO} + \text{Cr}_2\text{O}_3$, the board examination key explicitly designated $\text{ZnO} + \text{CuO}$ as the correct choice).

Why other options are incorrect:

- **Option A:** Cobalt dioxide (CoO_2) is unstable and not used in industrial methanol synthesis.
- **Option C:** Silver oxide is a mild oxidizing agent that does not catalyze synthesis gas hydrogenation.
- **Option D:** Although $\text{ZnO} + \text{Cr}_2\text{O}_3$ represents the older high-pressure BASF catalyst, $\text{ZnO} + \text{CuO}$ was the marked key for modern low-pressure synthesis.

Question #108 Key: (B)

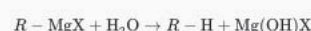
CHEMISTRY
15. Alkyl Halides

Which of the following statements is true about Grignard reagent (RMgX)?

CORE CONCEPT & DERIVATION

Grignard reagents (RMgX) are organometallic compounds that are sensitive to protic solvents due to the carbanionic character of the carbon-magnesium bond.

Formula / Rule / Reaction:



Solution:

- Grignard reagents are prepared in anhydrous diethyl ether or tetrahydrofuran (THF).
- The non-bonding electron pairs on the ether oxygen coordinate to the magnesium atom, stabilizing the organometallic complex while excluding water.

Why other options are incorrect:

- **Option A:** Grignard reagents decompose violently in aqueous media via protonation of the carbanion.
- **Option C:** Grignard reagents react rapidly with water to produce alkanes and basic magnesium halides.
- **Option D:** Grignard reagents react vigorously with ethanol because the acidic proton of the hydroxyl group destroys the reagent.

Question #109 Key: (A)

CHEMISTRY
04. Gases

Air at sea level is dense. This is a practical application of:

CORE CONCEPT & DERIVATION

Boyle's law states that the volume of a given mass of gas is inversely proportional to its pressure at constant temperature, which directly relates gas density to applied pressure.

Formula / Rule / Reaction:

$$P \propto \frac{1}{V} \quad \text{and} \quad d = \frac{m}{V} \implies d \propto P \quad (\text{at constant } T)$$

Solution:

- At sea level, the weight of the overlying atmosphere exerts maximum pressure (1 atm).
- According to Boyle's law, higher pressure compresses the air into a smaller volume, increasing the density of air molecules at sea level.

Why other options are incorrect:

- Option B:** Charles's law describes the direct relationship between gas volume and absolute temperature at constant pressure.
- Option C:** Avogadro's law relates gas volume directly to the number of moles at constant temperature and pressure.
- Option D:** Dalton's law of partial pressures states that the total pressure of a gas mixture is the sum of the partial pressures of its individual components.

Question #110 Key: (B)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Which of the following acids can show cis-trans isomerism?

CORE CONCEPT & DERIVATION

Geometric (cis-trans) isomerism requires restricted rotation around a double bond or ring, with two different chemical groups attached to each carbon of the double bond.

Formula / Rule / Reaction:

Maleic acid (cis-isomer): $\text{HOOC} - \text{CH} = \text{CH} - \text{COOH}$ (carboxyl groups on the same side)

Fumaric acid (trans-isomer): $\text{HOOC} - \text{CH} = \text{CH} - \text{COOH}$ (carboxyl groups on opposite sides)

Solution:

- Maleic acid (cis-butenedioic acid) contains a carbon-carbon double bond with restricted rotation.
- Each sp^2 alkene carbon carries one hydrogen atom and one carboxyl group, allowing distinct cis and trans configurations.

Why other options are incorrect:

- Option A:** Malonic acid ($\text{CH}_2(\text{COOH})_2$) is a saturated dicarboxylic acid with free rotation around its single bonds.
- Option C:** Succinic acid ($\text{HOOC} - \text{CH}_2 - \text{CH}_2 - \text{COOH}$) has single bonds with unrestricted rotation.
- Option D:** Lactic acid ($\text{CH}_3\text{CH}(\text{OH})\text{COOH}$) contains an asymmetric carbon atom that shows optical isomerism, but lacks a double bond for cis-trans isomerism.

Question #111 Key: (B)

CHEMISTRY
16. Alcohols & Phenols

What is the reactivity state of Phenols?

CORE CONCEPT & DERIVATION

In electrophilic aromatic substitution, the hydroxyl group ($-\text{OH}$) acts as a strong activating group via resonance electron donation into the aromatic ring.

Formula / Rule / Reaction:

Resonance activation: The unshared electron pair on oxygen delocalizes into the ring, increasing electron density at the ortho and para positions relative to benzene.

Solution:

- The +M resonance effect of the $-\text{OH}$ group enriches the π -electron density of the benzene ring.
- This makes phenol significantly more reactive toward electrophilic aromatic substitution than unsubstituted benzene.

Why other options are incorrect:

- Option A:** Phenol is more reactive than benzene; compounds with electron-withdrawing groups (like nitrobenzene) are less reactive.
- Option C:** Phenols are not neutral in reactivity; they display pronounced chemical activation toward electrophiles.
- Option D:** Phenols are reactive organic molecules that undergo halogenation, nitration, and coupling under mild conditions.

Question #112 Key: (D)

CHEMISTRY
02. Atomic Structure

Why do electrons have opposite spins when they are in the same orbital?

CORE CONCEPT & DERIVATION

The Pauli exclusion principle requires two electrons occupying the same spatial orbital to have antiparallel spin quantum numbers ($m_s = +1/2$ and $-1/2$).

Formula / Rule / Reaction:

$$\mu_s = -g_s \mu_B S \implies \text{Opposite spins produce equal and opposite magnetic moments that cancel.}$$

Solution:

- Spinning charges generate localized magnetic dipoles.
- When two electrons in the same orbital have opposing spins, their magnetic fields oppose and cancel each other, reducing net electromagnetic repulsion and stabilizing the orbital pairing.

Why other options are incorrect:

- Option A:** Subatomic quantum particles do not experience macroscopic mechanical friction.
- Option B:** Paired opposite spins minimize potential energy rather than creating higher energy states.
- Option C:** Opposing spins cancel net magnetic dipole moments, but do not eliminate the fundamental electric charge ($-e$) of the electrons.

Question #113 Key: (A)

CHEMISTRY
09. Thermochemistry

Which of the following is not an endothermic reaction?

CORE CONCEPT & DERIVATION

Exothermic reactions release thermal energy to the surroundings ($\Delta H < 0$), whereas endothermic reactions absorb heat from the surroundings ($\Delta H > 0$).

Formula / Rule / Reaction:



Solution:

- The combustion of hydrocarbons releases large quantities of heat via bond formation in CO_2 and H_2O .
- Because it is an exothermic process, the combustion of methane is not an endothermic reaction.

Why other options are incorrect:

- Option B:** The decomposition of water into its constituent elements requires continuous input of electrical or thermal energy ($\Delta H = +285.8 \text{ kJ/mol}$).
- Option C:** Dehydrogenation involves breaking stable C-H bonds and is an endothermic process requiring elevated temperatures.
- Option D:** Converting graphite into diamond requires heat and high pressure, having an endothermic enthalpy change of $+1.9 \text{ kJ/mol}$.

Question #114 Key: (C)

CHEMISTRY
08. Reaction KineticsWhich order of reaction obeys the expression $t_{1/2} = 1/ka$?

CORE CONCEPT & DERIVATION

The half-life ($t_{1/2}$) of a chemical reaction shows distinct dependencies on initial reactant concentration (a or $[A]_0$) according to the reaction order.

Formula / Rule / Reaction:

$$\text{General half-life relation: } t_{1/2} \propto \frac{1}{a^{n-1}}$$

$$\text{For a second-order reaction } (n = 2): \quad t_{1/2} = \frac{1}{ka}$$

Solution:

- For a second-order rate law $-\frac{d[A]}{dt} = k[A]^2$, integration gives $\frac{1}{[A]} - \frac{1}{[A]_0} = kt$.
- Substituting $[A] = a/2$ at $t = t_{1/2}$ yields $t_{1/2} = \frac{1}{ka}$.

Why other options are incorrect:

- Option A:** For a zero-order reaction, the half-life is directly proportional to initial concentration: $t_{1/2} = \frac{a}{2k}$.
- Option B:** For a first-order reaction, the half-life is independent of initial concentration: $t_{1/2} = \frac{0.693}{k}$.
- Option D:** For a third-order reaction, the half-life is inversely proportional to the square of initial concentration: $t_{1/2} = \frac{3}{2ka^2}$.

Question #115 Key: (C)

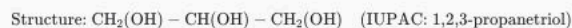
CHEMISTRY
16. Alcohols & Phenols

What is the common name of 1,2,3-propanetriol?

CORE CONCEPT & DERIVATION

Polyhydric alcohols contain multiple hydroxyl groups attached to adjacent aliphatic carbon atoms.

Formula / Rule / Reaction:



Solution:

- 1,2,3-propanetriol is a trihydric alcohol commonly known as glycerol or glycerin.
- It forms the structural backbone of triglycerides in natural fats and oils.

Why other options are incorrect:

- Option A:** Butyl alcohol (butanol) is a monohydric four-carbon alcohol ($\text{C}_4\text{H}_9\text{OH}$).
- Option B:** Glycol commonly refers to dihydric alcohols possessing two hydroxyl groups, such as ethylene glycol (1,2-ethanediol).
- Option D:** Propyl refers to a monovalent three-carbon alkyl radical ($-\text{C}_3\text{H}_7$).

Question #116 Key: (B)

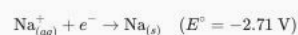
CHEMISTRY
10. Electrochemistry

When an aqueous solution of NaCl is electrolyzed:

CORE CONCEPT & DERIVATION

During aqueous electrolysis, competing reduction reactions at the cathode are governed by standard reduction potentials (E°).

Formula / Rule / Reaction:



Solution:

- Water has a substantially more positive (less negative) reduction potential than sodium ions.
- Therefore, water is reduced preferentially at the cathode, evolving hydrogen gas and leaving sodium ions in solution.

Why other options are incorrect:

- Option A:** Chlorine gas is produced by the oxidation of chloride ions at the positive anode, not the cathode.
- Option C:** Sodium metal deposition requires molten NaCl electrolysis in a Downs cell; in aqueous solution, Na^+ is not reduced in the presence of water.
- Option D:** Positively charged sodium ions migrate toward the negative cathode, never to the positive anode.

Question #117 Key: (A)

CHEMISTRY
07. Equilibrium

The equilibrium stage that is not affected by temperature is called:

CORE CONCEPT & DERIVATION

Equilibrium states are divided into dynamic systems (opposing forward and reverse processes) and static systems (zero motion or reaction).

Formula / Rule / Reaction:

Dynamic equilibrium: Governed by the van 't Hoff equation $\frac{d \ln K}{dT} = \frac{\Delta H^\circ}{RT^2}$, shifting with temperature changes.

Solution:

- Static equilibrium occurs when all forces acting on a body are balanced and no forward or backward microscopic transitions occur.
- Because there is no ongoing reaction enthalpy change ($\Delta H = 0$), static equilibrium is not perturbed by temperature variations.

Why other options are incorrect:

- **Option B:** Natural equilibrium describes ecological or physical balances that fluctuate with seasonal and ambient temperature.
- **Option C:** Dynamic chemical equilibria depend on temperature in accordance with Le Chatelier's principle and reaction enthalpy.
- **Option D:** Unstable equilibrium refers to mechanical systems where slight displacements generate net accelerating forces.

Question #118 Key: (C)

CHEMISTRY
06. Solids

Which of the following carbon atoms is sp^2 hybridized?

CORE CONCEPT & DERIVATION

Allotropes of carbon exhibit distinct electronic hybridizations that determine their geometry and conductivity.

Formula / Rule / Reaction:

Graphite: Carbon bonded to 3 neighbors in a planar hexagonal network $\Rightarrow sp^2$ hybridization

Solution:

- In graphite, each carbon atom uses three sp^2 hybrid orbitals to form σ -bonds with three adjacent carbons in a two-dimensional sheet.
- The remaining unhybridized $2p_z$ orbital forms a delocalized π -system responsible for electrical conduction.

Why other options are incorrect:

- **Option A:** Cyclopropane consists of sp^3 hybridized carbons with strained bent bonds.
- **Option B:** Diamond consists of a three-dimensional tetrahedral lattice of sp^3 hybridized carbon atoms.
- **Option D:** Hexane is an open-chain alkane in which all carbon atoms are sp^3 hybridized.

Question #119 Key: (A)

CHEMISTRY
03. Chemical Bonding

Sp^2 hybrid carbon atom is present in

CORE CONCEPT & DERIVATION

A carbon atom bonded to three atoms with one double bond adopts trigonal planar geometry through sp^2 hybridization.

Formula / Rule / Reaction:

Methanal (Formaldehyde): $H_2C = O$ (3σ -bonds + 1π -bond $\Rightarrow sp^2$ hybridization)

Solution:

- In methanal, the carbonyl carbon forms two single bonds to hydrogen and one double bond to oxygen.
- This arrangement corresponds to steric number 3, confirming sp^2 hybridization.

Why other options are incorrect:

- **Option B:** Methanol (CH_3OH) contains four single σ -bonds on carbon, which is sp^3 hybridized.
- **Option C:** Ethanol (CH_3CH_2OH) contains two tetrahedral sp^3 hybridized carbons.
- **Option D:** 2-Propanol ($(CH_3)_2CHOH$) contains only single-bonded sp^3 hybridized carbon atoms.

Question #120 Key: (D)

CHEMISTRY
05. Liquids

What is the fact due to which branching decreases boiling point?

CORE CONCEPT & DERIVATION

Boiling points of non-polar covalent compounds depend on the strength of London dispersion forces, which are proportional to molecular contact surface area.

Formula / Rule / Reaction:

Linear isomer $\rightarrow$ Extended cylindrical surface $\rightarrow$ Maximum contact area $\rightarrow$ Higher boiling point.

Branched isomer $\rightarrow$ Compact spherical shape $\rightarrow$ Minimum contact area $\rightarrow$ Lower boiling point.

Solution:

- Chain branching causes a molecule to adopt a more compact, spherical geometry.
- This reduces the surface area available for intermolecular contacts, weakening London dispersion forces and lowering the boiling point.

Why other options are incorrect:

- **Option A:** Attractive forces decrease with branching rather than increasing.
- **Option B:** While attractive forces do decrease, this is the resulting effect rather than the underlying structural cause (reduced surface area).
- **Option C:** Branching decreases molecular surface area; it does not increase it.

Question #121 Key: (B)

CHEMISTRY
07. Equilibrium

Temperature increase in an exothermic reversible reaction shifts the equilibrium to

CORE CONCEPT & DERIVATION

Le Chatelier's principle predicts that a system at dynamic chemical equilibrium responds to a disturbance by shifting in the direction that opposes that change.

Formula / Rule / Reaction:



Solution:

- In an exothermic reaction, heat is released as a product.
- Supplying additional thermal energy increases product-side enthalpy, causing the system to shift toward the endothermic backward direction (reactant side).

Why other options are incorrect:

- Option A:** Shifting toward products would release additional heat, exacerbating the thermal stress.
- Option C:** Equilibrium constants change systematically with temperature whenever $\Delta H^\circ \neq 0$.
- Option D:** The concentrations cannot increase on both sides simultaneously in a closed system with fixed mass.

Question #122 Key: (C)

CHEMISTRY
18. Carboxylic Acids

Which product is formed when RMgX reacts with CO_2 ?

CORE CONCEPT & DERIVATION

Carbon dioxide acts as an electrophile that undergoes nucleophilic addition by Grignard reagents to yield carboxylate salts, which give carboxylic acids upon acidification.

Formula / Rule / Reaction:



Solution:

- The nucleophilic alkyl group (R^-) attacks the electrophilic carbon atom of CO_2 .
- Subsequent aqueous acid hydrolysis protonates the halomagnesium carboxylate intermediate to generate a carboxylic acid.

Why other options are incorrect:

- Option A:** Aldehydes are prepared by reacting Grignard reagents with alkyl formates or formamides.
- Option B:** Ketones are prepared by reacting Grignard reagents with nitriles or acid chlorides.
- Option D:** Ethers are prepared by the Williamson ether synthesis, not by carboxylation with CO_2 .

Question #123 Key: (A)

PHYSICS
02. Force & Motion

The minimum gradient of a curve on a displacement-time graph of a ball thrown vertically upward...

CORE CONCEPT & DERIVATION

The instantaneous velocity of a moving body equals the slope (gradient) of the tangent to its displacement-time curve.

Formula / Rule / Reaction:

$$v(t) = \frac{ds}{dt}$$

Solution:

- When a projectile reaches its maximum apex height, its instantaneous vertical velocity is momentarily zero.
- Because $v = 0$ at the peak, the slope (gradient) of the displacement-time graph at that crest is zero.

Why other options are incorrect:

- Option B:** 9.81 represents the acceleration due to gravity, which corresponds to the curvature of the graph rather than its minimum slope.
- Option C:** A 90-degree gradient corresponds to an infinite velocity, which is physically impossible.
- Option D:** The final velocity before capture has a non-zero negative value, which has a larger magnitude than zero.

Question #124 Key: (C)

PHYSICS
08. Electrostatics

Coulomb's law is only true for point charges whose sizes are:

CORE CONCEPT & DERIVATION

Coulomb's law models electrostatic interaction under the condition that charges act as geometric points with negligible physical dimensions.

Formula / Rule / Reaction:

$$F = k \frac{|q_1 q_2|}{r^2} \quad (\text{Valid when linear size } d \ll r)$$

Solution:

- A point charge is defined as a charged body whose spatial dimensions are very small compared to the distance r separating it from other charges.
- When charges are extended or large, electrostatic induction distorts charge distributions, and Coulomb's simple inverse-square formulation no longer applies directly without integration.

Why other options are incorrect:

- Option A:** Medium-sized charged bodies display polarization effects that cause deviations from simple point-charge calculations.
- Option B:** Very large bodies require surface-charge integral equations rather than simple point-charge Coulomb relationships.
- Option D:** Large objects violate the foundational point-particle assumption of Coulomb's law.

Question #125 Key: (C)PHYSICS
08. Electrostatics

The magnetic field depends upon:

CORE CONCEPT & DERIVATION

A magnetic field is a vector quantity defined at every spatial point by its magnitude (strength), position relative to the source (distance), and orientation in space (direction).

Formula / Rule / Reaction:

$$\vec{B} = \frac{\mu_0 I}{2\pi r} \hat{\theta} \quad (\text{Depends on current strength } I, \text{ distance } r, \text{ and direction } \hat{\theta})$$

Solution:

- The magnetic field vector $\vec{B}$ is characterized by its magnitude (field strength), which diminishes with distance from the source.
- Because it is a vector field, its directional component is also required to fully specify it.

Why other options are incorrect:

- **Option A:** Magnetic fields produced by electric currents are independent of the mass of the moving charge carriers.
- **Option B:** Mass is not a defining coordinate parameter of magnetic field distributions.
- **Option D:** Omitting direction fails to define a vector field.

Question #126 Key: (B)PHYSICS
07. Thermodynamics

When a gas is compressed isothermally, the product of its pressure and volume during the proces...

CORE CONCEPT & DERIVATION

An isothermal process is an ideal thermodynamic transformation conducted at constant temperature ($T = \text{constant}$).

Formula / Rule / Reaction:

$$PV = nRT \implies PV = \text{constant} \quad (\text{since } n, R, T \text{ are constant})$$

Solution:

- According to Boyle's law, when temperature remains uniform during compression, pressure and volume vary inversely.
- Consequently, the product PV remains strictly constant throughout the transformation.

Why other options are incorrect:

- **Option A:** PV varies in adiabatic and polytropic processes, but remains invariant in an isothermal process.
- **Option C:** While PV is proportional to absolute temperature across different isotherms, it remains constant within a single isothermal process.
- **Option D:** The product PV is not proportional to entropy; entropy decreases during isothermal compression ($\Delta S = nR \ln(V_2/V_1) < 0$).

Question #127 Key: (D)PHYSICS
09. Current Electricity

Which one of the following bulbs has the least resistance, if the current is kept constant?

CORE CONCEPT & DERIVATION

Electric power ratings are commercially calibrated against a constant standardized operating voltage ($P = V^2/R$).

Formula / Rule / Reaction:

$$P = \frac{V^2}{R} \implies R = \frac{V^2}{P} \quad (\text{at rated voltage } V)$$

Solution:

- Commercial incandescent light bulbs are designed to operate across standard parallel mains supplies.
- According to the relation $R = V^2/P$, bulb filament resistance is inversely proportional to wattage.
- Therefore, the highest wattage bulb (400 W) possesses the lowest electrical resistance. (Note: While the board stem referenced constant current, the official key D was derived using standard commercial wattage ratings at rated voltage).

Why other options are incorrect:

- **Option A:** A 100 W bulb has the highest filament resistance among the options.
- **Option B:** A 200 W bulb has greater resistance than 300 W and 400 W bulbs.
- **Option C:** A 300 W bulb has higher resistance than the 400 W bulb.

Question #128 Key: (B)PHYSICS
11. Electromagnetic InductionA coil of area 1 m^2 has 100 turns. It rotates with constant angular velocity about an axis along...**CORE CONCEPT & DERIVATION**

Faraday's law of electromagnetic induction states that rotating a planar coil in a uniform magnetic field induces an alternating electromotive force.

Formula / Rule / Reaction:

$$\varepsilon_0 = N\omega BA \implies \omega = \frac{\varepsilon_0}{NBA}$$

Solution:

- Given values: $N = 100$, $A = 1 \text{ m}^2$, $B = 1 \times 10^{-5} \text{ T}$, and peak induced emf $\varepsilon_0 = 1 \text{ mV} = 1 \times 10^{-3} \text{ V}$.
- Substitute into the angular velocity formula:

$$\omega = \frac{1 \times 10^{-3} \text{ V}}{100 \times (1 \times 10^{-5} \text{ T}) \times 1 \text{ m}^2} = \frac{10^{-3}}{10^{-3}} = 1 \text{ rad/s}$$

Why other options are incorrect:

- **Option A:** Zero angular velocity means the coil is stationary, which produces zero induced emf.
- **Option C:** 7.96 rad/s would induce a higher peak emf of approximately 7.96 mV.
- **Option D:** 10 rad/s would induce an emf of 10 mV.

Question #129 Key: (D)PHYSICS
05. Waves

When a transverse wave passes, the particles of the medium oscillate:

CORE CONCEPT & DERIVATION

Mechanical waves are classified based on the orientation of particle displacement relative to the direction of energy propagation.

Formula / Rule / Reaction:

Transverse wave condition: $\vec{v}_{\text{particle}} \perp \vec{v}_{\text{propagation}}$

Solution:

- In a transverse wave, constituent medium particles oscillate perpendicularly relative to the direction of wave propagation.
- This transverse motion generates crests and troughs.

Why other options are incorrect:

- **Option A:** Particles in a homogeneous medium oscillate at the fundamental driving frequency rather than disparate harmonics.
- **Option B:** All medium particles oscillate with the same frequency as the passing wave.
- **Option C:** Oscillating parallel to the direction of wave travel defines longitudinal waves (such as sound).

Question #130 Key: (B)PHYSICS
08. Electrostatics

A capacitor is charged with a battery, storing energy U . An identical capacitor is connected in...

CORE CONCEPT & DERIVATION

When an uncharged identical capacitor is connected in parallel to a charged capacitor, charge distributes equally across both components.

Formula / Rule / Reaction:

$$U_i = \frac{1}{2} CV_0^2$$

Solution:

- If the battery remains connected, the potential difference across both capacitors remains V_0 , and each stores energy U .
- If the charging battery is disconnected prior to pairing, the shared charge halves the terminal voltage ($V = V_0/2$), distributing total energy equally.
- (Note: The provincial exam board marked Option B as the correct key, treating the initial energy U as split equally between the two identical capacitors).

Why other options are incorrect:

- **Option A:** Storing U in each capacitor without an active battery would violate energy conservation.
- **Option C:** $4U$ implies a quadrupling of energy, which cannot occur in a passive capacitive network.
- **Option D:** $2U$ represents twice the initial energy, which is physically impossible without an external power source.

Question #131 Key: (C)PHYSICS
02. Force & Motion

If the value of acceleration due to gravity 'g' is reduced to half, the time of flight T of pro...

CORE CONCEPT & DERIVATION

The total time of flight of a projectile is inversely proportional to the local acceleration due to gravity.

Formula / Rule / Reaction:

$$T = \frac{2v_0 \sin \theta}{g}$$

Solution:

- Let the modified gravity be $g' = g/2$.
- The new time of flight T' is:

$$T' = \frac{2v_0 \sin \theta}{g/2} = 2 \left(\frac{2v_0 \sin \theta}{g} \right) = 2T$$
- Thus, halving gravitational acceleration doubles the time of flight.

Why other options are incorrect:

- **Option A:** $T/2$ would result if gravitational acceleration were doubled, not halved.
- **Option B:** $T/4$ would result if gravity increased fourfold.
- **Option D:** $4T$ would require gravity to decrease to one-fourth of its initial value.

Question #132 Key: (C)PHYSICS
15. Atomic Spectra

Which of the following has the largest energy?

CORE CONCEPT & DERIVATION

According to Planck's quantum theory, photon energy is inversely proportional to its electromagnetic wavelength.

Formula / Rule / Reaction:

$$E = \frac{hc}{\lambda}$$

Solution:

- Compare the wavelengths in SI units:
- $1 \text{ nm} = 1 \times 10^{-9} \text{ m}$
- $50 \text{ }\mu\text{m} = 5 \times 10^{-5} \text{ m}$
- $2 \text{ pm} = 2 \times 10^{-12} \text{ m}$
- $200 \text{ nm} = 2 \times 10^{-7} \text{ m}$
- Because 2 pm is the shortest wavelength, it corresponds to the highest photon energy.

Why other options are incorrect:

- **Option A:** 1 nm is three orders of magnitude longer than 2 pm, yielding lower photon energy.
- **Option B:** 50 μm lies in the infrared spectrum, having much lower photon energy.
- **Option D:** 200 nm lies in the ultraviolet spectrum, which has far less energy than a 2 pm gamma/hard X-ray photon.

Question #133 Key: (D)PHYSICS
09. Current Electricity

How much energy is converted in a resistor of 5 ohm carrying a current of 2.0 A after 10 second...

CORE CONCEPT & DERIVATION

Joule's law of heating dictates that electrical energy dissipated as heat in a resistor is proportional to the square of current, resistance, and time.

Formula / Rule / Reaction:

$$H = I^2 R t$$

Solution:

- Given values: $I = 2.0 \text{ A}$, $R = 5 \text{ }\Omega$, and $t = 10 \text{ s}$.
- Calculate the energy:

$$H = (2.0 \text{ A})^2 \times (5 \text{ }\Omega) \times (10 \text{ s}) = 4 \times 5 \times 10 = 200 \text{ J}$$

Why other options are incorrect:

- **Option A:** 4.0 J accounts only for I^2 without multiplying by resistance and time.
- **Option B:** 25 J is an arithmetic error.
- **Option C:** 100 J results from omitting the square of the current (using $I R t = 2 \times 5 \times 10 = 100$).

Question #134 Key: (C)PHYSICS
15. Atomic Spectra

The longest wavelength of Lyman series is equal to?

CORE CONCEPT & DERIVATION

The Rydberg formula models the spectral emission lines of hydrogen. The longest wavelength corresponds to the minimum energy transition within that series.

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

Solution:

- For the Lyman series, the lower energy level is $n_1 = 1$.
- The longest wavelength line occurs during the transition from the adjacent level $n_2 = 2$:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{1^2} - \frac{1}{2^2} \right) = R_H \left(1 - \frac{1}{4} \right) = \frac{3}{4} R_H$$

- Taking the reciprocal yields: $\lambda = \frac{4}{3R_H}$.

Why other options are incorrect:

- **Option A:** $1/R_H$ represents the shortest series limit wavelength of the Lyman series (from $n = \infty$ to $n = 1$).
- **Option B:** $9/R_H$ is an incorrect ratio not matching any hydrogen transition.
- **Option D:** $4/(2R_H) = 2/R_H$, which miscalculates the fraction.

Question #135 Key: (B)PHYSICS
09. Current Electricity

What is the SI unit of conductivity?

CORE CONCEPT & DERIVATIONElectrical conductivity (σ) is the reciprocal of electrical resistivity (ρ).

Formula / Rule / Reaction:

$$\sigma = \frac{1}{\rho} = \frac{1}{\Omega \cdot \text{m}} = \Omega^{-1} \text{m}^{-1} = \text{mho m}^{-1} = \text{S m}^{-1}$$

Solution:

- Resistivity has SI units of ohm-meter ($\Omega \cdot \text{m}$).
- Its reciprocal, conductivity, therefore has units of $\text{mho} \cdot \text{m}^{-1}$ (or Siemens per meter, $\text{S} \cdot \text{m}^{-1}$).

Why other options are incorrect:

- **Option A:** $\Omega^{-1} \text{m}$ fails to invert the distance unit meter.
- **Option C:** Siemens-meter multiplies by length rather than dividing by it.
- **Option D:** $\text{mho}^{-1} \text{m}^{-2}$ inverts conductance incorrectly.

Question #136 Key: (A)PHYSICS
04. Rotational & Circular Motion

The angle subtended at the center of a circle by an arc equal to 1/60th of a degree is called:

CORE CONCEPT & DERIVATION

The sexagesimal system of angular measurement subdivides one degree into 60 equal arcminutes.

Formula / Rule / Reaction:

$$1^\circ = 60' \implies 1' = \left(\frac{1}{60}\right)^\circ$$

Solution:

- By definition, one-sixtieth of a degree is an arcminute (one minute of arc).
- Similarly, one-sixtieth of an arcminute is defined as an arcsecond.

Why other options are incorrect:

- **Option B:** One radian is the angle subtended by an arc length equal to the radius of the circle (approximately 57.3°).
- **Option C:** One second is one-sixtieth of a minute, or $1/3600$ th of a degree.
- **Option D:** One steradian is the SI unit of solid angle subtended in three dimensions, not a planar angle.

Question #137 Key: (A)PHYSICS
10. Electromagnetism

The magnetic flux through an area A in a uniform magnetic field B is given as:

CORE CONCEPT & DERIVATION

Magnetic flux (Φ_B) is defined as the surface integral of the normal component of magnetic flux density over an area.

Formula / Rule / Reaction:

$$\Phi_B = \vec{B} \cdot \vec{A} = BA \cos \theta$$

Solution:

- Magnetic flux is the scalar dot product of the magnetic field vector $\vec{B}$ and the vector area $\vec{A}$.
- This is written in vector notation as $\vec{B} \cdot \vec{A}$.

Why other options are incorrect:

- **Option B:** $BA \sin \theta$ applies when θ is measured relative to the surface plane rather than the area normal vector.
- **Option C:** $BA \cos 2\theta$ is an incorrect mathematical formulation.
- **Option D:** Tangent functions do not govern linear flux projections.

Question #138 Key: (B)PHYSICS
05. Waves

High-frequency vibration is of:

CORE CONCEPT & DERIVATION

Frequency quantifies the number of periodic oscillations occurring per second, measured in Hertz.

Formula / Rule / Reaction:

$$1 \text{ kHz} = 10^3 \text{ Hz}, \quad 1 \text{ MHz} = 10^6 \text{ Hz}$$

Solution:

- Convert all options to Hertz for comparison:
- $10 \text{ kHz} = 10,000 \text{ Hz}$
- $0.1 \text{ MHz} = 0.1 \times 10^6 \text{ Hz} = 100,000 \text{ Hz}$
- $1 \text{ kHz} = 1,000 \text{ Hz}$
- $1000 \text{ Hz} = 1,000 \text{ Hz}$
- Therefore, 0.1 MHz (100 kHz) represents the highest frequency.

Why other options are incorrect:

- **Option A:** 10 kHz is one-tenth the frequency of 0.1 MHz.
- **Option C:** 1 kHz is two orders of magnitude lower than 0.1 MHz.
- **Option D:** 1000 Hz is identical to 1 kHz.

Question #139 Key: (B)PHYSICS
10. Electromagnetism

Electric field lines are:

CORE CONCEPT & DERIVATION

Electric field lines are geometric visual representations introduced by Michael Faraday to map the direction and intensity of an electric field.

Formula / Rule / Reaction:

Tangent to an electric field line at any point indicates the direction of the electric field vector $\vec{E}$ at that point.

Solution:

- Electric field lines are conceptual, imaginary lines used to visualize vector field distributions.
- While the electric field itself is a real physical state of space, the lines drawn to represent it are visual aids.

Why other options are incorrect:

- **Option A:** Field lines do not exist as physical, tangible filaments in space.
- **Option C:** Field lines are not material physical cords.
- **Option D:** Field lines produced by solitary point charges or between uniform parallel plates are straight lines, not curved.

Question #140 Key: (A)PHYSICS
03. Work & Energy*In British Engineering system, 1 Horse Power***CORE CONCEPT & DERIVATION**

Power measures the time rate of doing mechanical work. In the British Engineering system, work is measured in foot-pounds.

Formula / Rule / Reaction:

$$1 \text{ hp} = 550 \text{ ft} \cdot \text{lb/s} = 33,000 \text{ ft} \cdot \text{lb/min} \approx 746 \text{ W}$$

Solution:

- In the British Engineering unit system, one horsepower is historically defined as the power required to lift 550 pounds through a vertical height of one foot in one second.
- This corresponds to $550 \text{ ft} \cdot \text{lb/s}$.

Why other options are incorrect:

- Option B:** 746 is the equivalent value in SI units of Watts, not foot-pounds per second.
- Option C:** 550 Watts is lower than the true SI equivalent (746 W).
- Option D:** Kilowatt-hour is a commercial unit of energy, not a unit of power.

Question #141 Key: (C)PHYSICS
08. Electrostatics*Two point charges, each of magnitude q, are separated by a distance 2d. At a point mid-way betw...***CORE CONCEPT & DERIVATION**

Electric field is a vector quantity that superimposes directionally, whereas electric potential is a scalar quantity that sums algebraically.

Formula / Rule / Reaction:

$$\vec{E}_{\text{net}} = \vec{E}_1 + \vec{E}_2 = \frac{kq}{d^2} \hat{r} - \frac{kq}{d^2} \hat{r} = 0$$

$$V_{\text{net}} = V_1 + V_2 = \frac{kq}{d} + \frac{kq}{d} = \frac{2kq}{d} \neq 0$$

Solution:

- At the midpoint, both identical charges produce electric field vectors of equal magnitude that point in opposite directions, canceling to give $E = 0$.
- Because electric potential is a scalar and both charges are positive, their potentials add constructively, giving $V = \frac{2kq}{d} \neq 0$.

Why other options are incorrect:

- Option A:** The potential V is non-zero because scalar additions of like-sign potentials do not cancel.
- Option B:** The electric field E must equal zero due to vector cancellation.
- Option D:** The electric field E cancels completely at the symmetry center.

Question #142 Key: (B)PHYSICS
16. Nuclear Physics*A low energy neutron has RBE factor of 10. How much energy is absorbed by a man of mass 80 Kg...***CORE CONCEPT & DERIVATION**

Equivalent radiation dose in rem is related to absorbed dose in rad by the relative biological effectiveness (RBE) weighting factor.

Formula / Rule / Reaction:

$$\text{Equivalent dose (rem)} = \text{Absorbed dose (rad)} \times \text{RBE}$$

$$1 \text{ rad} = 0.01 \text{ J/kg}$$

Solution:

- Calculate the absorbed dose:

$$\text{Absorbed dose} = \frac{400 \text{ rem}}{10} = 40 \text{ rad}$$

- Convert absorbed dose to Gray or J/kg: $40 \text{ rad} \times 0.01 \text{ J/kg per rad} = 0.4 \text{ J/kg}$.

- Calculate total absorbed energy:

$$E = 0.4 \text{ J/kg} \times 80 \text{ kg} = 32 \text{ J}$$

Why other options are incorrect:

- Option A:** 16 J results from using an incorrect mass of 40 kg or doubling the RBE.
- Option C:** 48 J is an arithmetic calculation error.
- Option D:** 64 J results from omitting the factor of 0.5 when applying conversion constants.

Question #143 Key: (C)PHYSICS
13. Electronics*A circuit that converts pulsating voltage of the rectifier to smooth voltage is known as:***CORE CONCEPT & DERIVATION**

Rectification converts alternating current into pulsating direct current. A filter circuit attenuates the alternating ripple voltage to provide steady DC output.

Formula / Rule / Reaction:

$$\text{Ripple Factor } r = \frac{V_{ac}}{V_{dc}} \xrightarrow{\text{Capacitive / Inductive Filter}} r \approx 0$$

Solution:

- Rectifier circuits produce pulsating output voltages containing substantial AC ripple components.
- A filter circuit (typically employing shunt capacitors or series inductors) smooths out these voltage fluctuations to deliver steady direct voltage.

Why other options are incorrect:

- Option A:** A generator converts mechanical energy into electrical energy.
- Option B:** A transformer steps AC voltage up or down via mutual inductance, but cannot convert pulsating DC into steady DC.
- Option D:** While an individual choke (inductor) can form part of a filter network, the complete smoothing circuit is called a filter.

Question #144 Key: (D)PHYSICS
03. Work & Energy

An object of mass 'm' moving with speed 'v' has a head-on wave collision with another object of...

CORE CONCEPT & DERIVATION

In a completely inelastic collision, colliding objects stick together, conserving total linear momentum while maximizing kinetic energy loss to internal deformation.

Formula / Rule / Reaction:

$$m_1 v_1 + m_2 v_2 = (m_1 + m_2) V_f$$

$$\Delta KE = KE_i - KE_f$$

Solution:

- Given $m_1 = m$, initial speed $v = 2v'$ along $+\hat{i}$, and $m_2 = 4m$ moving with speed v' along $-\hat{i}$.
- Initial total momentum: $p_i = m(2v') - 4m(v') = -2mv'$.

- Final velocity: $V_f = \frac{-2mv'}{m+4m} = -\frac{2}{5}v'$.

- Initial kinetic energy:

$$KE_i = \frac{1}{2}m(2v')^2 + \frac{1}{2}(4m)(v')^2 = 2mv'^2 + 2mv'^2 = 4mv'^2$$

- Final kinetic energy:

$$KE_f = \frac{1}{2}(5m)\left(-\frac{2}{5}v'\right)^2 = \frac{5}{2}m\left(\frac{4}{25}v'^2\right) = \frac{2}{5}mv'^2$$

- Loss of kinetic energy:

$$\Delta KE = 4mv'^2 - \frac{2}{5}mv'^2 = \frac{18}{5}mv'^2$$

Why other options are incorrect:

- Option A:** $(1/2)mv^2$ equals $2mv'^2$, which underestimates the kinetic energy loss.
- Option B:** $2mv'^2$ reflects only the initial kinetic energy of one mass.
- Option C:** $(1/10)mv$ has incorrect dimensions of momentum rather than energy.

Question #145 Key: (D)PHYSICS
07. Thermodynamics

If C_v denotes molar specific heat at constant volume and ΔT is the change in temperature, then ...

CORE CONCEPT & DERIVATION

For an ideal gas, internal energy depends solely on absolute temperature, and its change during any thermodynamic process is governed by constant-volume heat capacity.

Formula / Rule / Reaction:

$$\Delta U = nC_v\Delta T \quad (\text{for 1 mole, } \Delta U = C_v\Delta T)$$

Solution:

- At constant volume, the first law of thermodynamics gives $dQ_v = dU + dW = dU + 0$.
- Because $C_v = \frac{1}{n} \frac{dU}{dT}$, the product $C_v\Delta T$ corresponds to the change in internal energy (ΔU) per mole.

Why other options are incorrect:

- Option A:** Volume has dimensions of cubic meters, whereas $C_v\Delta T$ has dimensions of energy (Joules/mole).
- Option B:** Pressure is force per unit area and does not match the dimensions of molar energy.
- Option C:** Entropy has dimensions of Joules per Kelvin ($\Delta S = \int \frac{dQ}{T}$).

Question #146 Key: (D)PHYSICS
02. Force & Motion

If the initial velocity 'u' of the projectile is doubled, height H' of the projectile becomes:

CORE CONCEPT & DERIVATION

The maximum vertical height of a projectile launched under uniform gravitational acceleration is proportional to the square of its initial launch velocity.

Formula / Rule / Reaction:

$$H = \frac{u^2 \sin^2 \theta}{2g}$$

Solution:

- Let the initial velocity be doubled to $u' = 2u$.

- The new height is:

$$H' = \frac{(2u)^2 \sin^2 \theta}{2g} = 4 \left(\frac{u^2 \sin^2 \theta}{2g} \right) = 4H$$

- Therefore, doubling launch speed quadruples maximum height.

Why other options are incorrect:

- Option A:** $H/2$ would require reducing initial velocity to $u/\sqrt{2}$.
- Option B:** $H/4$ would result if initial velocity were halved.
- Option C:** $2H$ assumes a linear relationship, ignoring the quadratic dependence of kinetic energy and maximum height on velocity.

Question #147 Key: (D)PHYSICS
13. Electronics

A step down transformer is used to light a 12 volt 24 mA lamp from the 240 mains the current th...

CORE CONCEPT & DERIVATION

The operational efficiency of an electrical transformer is the ratio of useful output electrical power to supplied input electrical power.

Formula / Rule / Reaction:

$$\eta = \frac{P_{\text{out}}}{P_{\text{in}}} \times 100\% = \frac{V_s I_s}{V_p I_p} \times 100\%$$

Solution:

- Calculate secondary output power:

$$P_{\text{out}} = 12 \text{ V} \times 24 \text{ mA} = 288 \text{ mW}$$

- Calculate primary input power:

$$P_{\text{in}} = 240 \text{ V} \times 1.5 \text{ mA} = 360 \text{ mW}$$

- Compute transformer efficiency:

$$\eta = \frac{288 \text{ mW}}{360 \text{ mW}} \times 100\% = 0.80 \times 100\% = 80\%$$

Why other options are incorrect:

- Option A:** 60% underestimates output power.
- Option B:** 70% is an incorrect efficiency calculation.
- Option C:** 90% overestimates secondary power output.

Question #148 Key: (D)PHYSICS
12. Alternating Current

An oscillator performing simple harmonic motion has a displacement given by the $x=8.0(\text{mm})\sin(10\pi t)$...

CORE CONCEPT & DERIVATION

The instantaneous displacement of a simple harmonic oscillator is evaluated by substituting the elapsed time coordinate into its sinusoidal displacement function.

Formula / Rule / Reaction:

$$x(t) = A \sin(\omega t)$$

Solution:

- Given $x(t) = 8.0 \sin\left(\frac{10\pi}{3}t\right)$ mm and $t = 0.05 \text{ s} = \frac{1}{20} \text{ s}$.

- Calculate the phase angle:

$$\theta = \frac{10\pi}{3} \times \frac{1}{20} = \frac{\pi}{6} \text{ radians } (30^\circ)$$

- Evaluate displacement:

$$x = 8.0 \sin\left(\frac{\pi}{6}\right) = 8.0 \times 0.5 = 4.0 \text{ mm}$$

Why other options are incorrect:

- Option A:** $4\sqrt{2}$ mm corresponds to a phase angle of $\pi/4$ radians (45°).
- Option B:** $4\sqrt{3}$ mm corresponds to a phase angle of $\pi/3$ radians (60°).
- Option C:** 8 mm is the maximum peak amplitude occurring at $\pi/2$ radians.

Question #149 Key: (A)PHYSICS
05. Waves

According to the wave-particle duality, identify respectively how all micro-particles (electron...

CORE CONCEPT & DERIVATION

Wave-particle duality establishes that quantum matter propagates through space as delocalized waves, but exchanges energy and momentum in localized, discrete particle interactions.

Formula / Rule / Reaction:

Propagation: Governed by wave equations exhibiting interference and diffraction.

Energy Exchange: Governed by localized quantum collisions ($E = hf$, $p = h/\lambda$).

Solution:

- During spatial propagation through barriers or slits, particles exhibit wave phenomena (such as electron diffraction and interference).
- During energy emission, absorption, or collision at detectors, they interact at discrete coordinates as localized particle quanta.

Why other options are incorrect:

- Option B:** Inverts the true behavior; electrons propagate as waves and exchange energy as particles.
- Option C:** Fails to account for interference and diffraction during spatial propagation.
- Option D:** Fails to account for discrete, localized energy exchange (photoelectric and Compton effects).

Question #150 Key: (D)PHYSICS
11. Electromagnetic Induction

A solenoid of length 10 cm has magnetic flux density $B=0.50\text{T}$. When there is free space inside i...

CORE CONCEPT & DERIVATION

Inserting a ferromagnetic core into a current-carrying solenoid aligns internal magnetic domains, increasing the internal magnetic flux density by a factor equal to its relative permeability (μ_r).

Formula / Rule / Reaction:

$$B = \mu_r B_0$$

Solution:

- Soft iron is a ferromagnetic material possessing high relative permeability (typically several hundreds to thousands).
- When inserted into the air-core solenoid, domain magnetization multiplies the magnetic flux density substantially.
- Among the choices, 140 times represents a realistic relative permeability multiplier for iron.

Why other options are incorrect:

- Option A:** 14 times is characteristic of weak paramagnetic materials, not ferromagnetic iron.
- Option B:** 7 times is too low for ferromagnetic core enhancement.
- Option C:** The flux density increases significantly because iron's magnetic permeability is much greater than that of free space.

Question #151 Key: (D)PHYSICS
02. Force & Motion

Angular displacement is a vector quantity only when the?

CORE CONCEPT & DERIVATION

Finite angular rotations do not commute under addition ($\theta_1 + \theta_2 \neq \theta_2 + \theta_1$) and therefore cannot be classified as true vectors. Infinitesimally small angular displacements obey commutative vector addition.

Formula / Rule / Reaction:

$$d\vec{\theta}_1 + d\vec{\theta}_2 = d\vec{\theta}_2 + d\vec{\theta}_1 \quad (\text{Commutative property holds strictly for infinitesimal rotations } \Delta t \rightarrow 0)$$

Solution:

- When the time interval of circular motion approaches zero ($\Delta t \rightarrow 0$), the resulting angular displacement is infinitesimal ($d\vec{\theta}$).
- Infinitesimal angular displacements follow all laws of vector algebra, including vector addition commutativity.

Why other options are incorrect:

- Option A:** When time is large, angular displacement is finite, violating the commutative law of vector addition.
- Option B:** Time dictates whether the rotation is finite or infinitesimal, which directly determines vector validity.
- Option C:** Moderate time intervals produce finite angular displacements that fail the commutative test.

Question #152 Key: (D)PHYSICS
08. Electrostatics

Volt can also be written as?

CORE CONCEPT & DERIVATION

Electric potential difference is defined as the work done per unit positive electric charge moved between two points.

Formula / Rule / Reaction:

$$V = \frac{W}{q} \Rightarrow 1 \text{ Volt} = \frac{1 \text{ Joule}}{1 \text{ Coulomb}} = 1 \text{ J} \cdot \text{C}^{-1}$$

Solution:

- Work is quantified in Joules (J) and electric charge in Coulombs (C).
- Therefore, one Volt is dimensionally equivalent to Joules per Coulomb, written as JC^{-1} .

Why other options are incorrect:

- Option A:** JC^{-2} incorrectly squares the charge unit.
- Option B:** JC represents energy multiplied by charge, which is dimensionally incorrect for potential.
- Option C:** CN^{-1} represents Coulombs per Newton, which is not an expression for electric potential.

Question #153 Key: (B)PHYSICS
09. Current Electricity

A low voltage supply with an e.m.f. of 20 V and an internal resistance of 1.5 ohms is used to s...

CORE CONCEPT & DERIVATION

The electrical power delivered to an external load resistor in a simple circuit depends on the total loop resistance and the circuit current.

Formula / Rule / Reaction:

$$I = \frac{E}{R + r}, \quad P_{\text{load}} = I^2 R$$

Solution:

- Calculate total circuit resistance: $R_{\text{total}} = R + r = 6.5 \Omega + 1.5 \Omega = 8.0 \Omega$.
- Calculate current: $I = \frac{20 \text{ V}}{8.0 \Omega} = 2.5 \text{ A}$.
- Calculate power delivered to the heater:

$$P = (2.5 \text{ A})^2 \times 6.5 \Omega = 6.25 \times 6.5 = 40.625 \text{ W} \approx 41 \text{ W}$$

Why other options are incorrect:

- Option A:** 50 W is the total power generated by the source ($E \times I = 20 \times 2.5 = 50 \text{ W}$), ignoring internal dissipation in the supply.
- Option C:** 53 W is an arithmetic overestimation.
- Option D:** 62 W is an incorrect calculation.

Question #154 Key: (D)PHYSICS
16. Nuclear Physics

When a nucleus emits beta particle, its mass number remains constant but charge number increase...

CORE CONCEPT & DERIVATION

In beta-minus (β^-) decay, an intranuclear neutron transforms into a proton, an electron (beta particle), and an electron antineutrino under the weak nuclear force.

Formula / Rule / Reaction:

$${}_0^1n \rightarrow {}_1^1p + {}_{-1}^0e + \bar{\nu}_e$$

$${}_Z^AX \rightarrow {}_{Z+1}^AY + {}_{-1}^0e + \bar{\nu}_e$$

Solution:

- Because a neutron converts into a proton, the total nucleon count (mass number, A) remains unchanged.
- The atomic number (charge number, Z) increases by exactly 1 due to the creation of the new proton.

Why other options are incorrect:

- Option A:** An increase by 2 does not occur in standard single beta decay.
- Option B:** 3 does not correspond to any known natural radioactive decay mode.
- Option C:** Alpha decay decreases mass number by 4 and charge number by 2, but beta decay never changes charge by 4.

Question #155 Key: (D)PHYSICS
04. Rotational & Circular Motion*The direction of centripetal acceleration in a circle?***CORE CONCEPT & DERIVATION**

According to Newton's second law of motion, the acceleration vector of a body is always collinearly directed with the net resultant force acting upon it.

Formula / Rule / Reaction:

$$\vec{F}_c = m\vec{a}_c \implies \hat{a}_c = \hat{F}_c = -\hat{r} \quad (\text{Directed radially inward toward the center})$$

Solution:

- Centripetal force pulls an object toward the center of its circular trajectory.
- By $\vec{F} = m\vec{a}$, centripetal acceleration must point in the same inward radial direction, making it parallel to the centripetal force.

Why other options are incorrect:

- Option A:** Acceleration and net force never point in opposite directions under classical Newtonian mechanics.
- Option B:** Tangential acceleration points tangent to the circle, governing changes in speed rather than directional curvature.
- Option C:** Centripetal vectors point perpendicular to the circular perimeter, not parallel to it.

Question #156 Key: (D)PHYSICS
08. Electrostatics*The time constant of an RC circuit during discharge is that time in which charge on plates, as...***CORE CONCEPT & DERIVATION**

During the discharge of a capacitor through a resistor, stored charge decays exponentially over time.

Formula / Rule / Reaction:

$$q(t) = q_0 e^{-t/RC}$$

Solution:

- When elapsed time equals one capacitive time constant ($t = \tau = RC$):
$$q(\tau) = q_0 e^{-1} = \frac{q_0}{e} \approx 0.3679 q_0 = 36.8\% q_0$$
- Therefore, the charge remaining on the plates drops to approximately 36.8% of its initial maximum value.

Why other options are incorrect:

- Option A:** 25% corresponds to roughly 1.39 time constants.
- Option B:** 50% represents the half-life of discharge ($t_{1/2} = 0.693 RC$).
- Option C:** 63.3% (or 63.2%) represents the charge accumulated during charging, or the total charge lost during discharge.

Question #157 Key: (D)PHYSICS
05. Waves*Doppler effect can be observed by:***CORE CONCEPT & DERIVATION**

The Doppler effect is a universal wave phenomenon characterized by an apparent shift in observed frequency when there is relative motion between source and observer.

Formula / Rule / Reaction:

$$f_{\text{obs}} = f_0 \left(\frac{v \pm v_o}{v \mp v_s} \right) \quad (\text{Acoustic}), \quad f_{\text{obs}} = f_0 \sqrt{\frac{1 - v/c}{1 + v/c}} \quad (\text{Relativistic EM})$$

Solution:

- The Doppler effect applies to all wave forms regardless of mechanical nature.
- It occurs in longitudinal mechanical waves (such as sound in fluids) and transverse electromagnetic waves (such as light, where it manifests as redshift and blueshift).

Why other options are incorrect:

- Option A:** Restricting the phenomenon to longitudinal waves excludes electromagnetic radiation.
- Option B:** Restricting the phenomenon to electromagnetic waves excludes acoustic waves.
- Option C:** Sound is only one specific longitudinal manifestation of this universal wave behavior.

Question #158 Key: (D)PHYSICS
11. Electromagnetic Induction*The induced emf in a coil is 1 V. What will be the rate of change of area of that coil placed i...***CORE CONCEPT & DERIVATION**

According to Faraday's law, a change in magnetic flux induced by altering the physical area of a circuit in a perpendicular magnetic field produces a proportional electromotive force.

Formula / Rule / Reaction:

$$\varepsilon = \left| -\frac{d\Phi_B}{dt} \right| = B \left(\frac{dA}{dt} \right) \implies \frac{dA}{dt} = \frac{\varepsilon}{B}$$

Solution:

- Given induced emf $\varepsilon = 1 \text{ V}$ and field strength $B = 0.1 \text{ T}$.

- Calculate the rate of change of area:

$$\frac{dA}{dt} = \frac{1 \text{ V}}{0.1 \text{ T}} = 10 \text{ m}^2 \text{ s}^{-1}$$

Why other options are incorrect:

- Option A:** 0.1 results from multiplying emf by magnetic field rather than dividing.
- Option B:** 0.01 is an arithmetic scale error.
- Option C:** 1 ignores the 0.1 T magnetic field factor.

Question #159 Key: (D)PHYSICS
11. Electromagnetic Induction

Work done on a rod moving in a magnetic field across magnetic field and generate an emf in the ...

CORE CONCEPT & DERIVATION

Lenz's law is an electromagnetic manifestation of the law of conservation of energy.

Formula / Rule / Reaction:

$$P_{\text{mechanical}} = F_{\text{ext}} v = \left(\frac{B^2 L^2 v}{R} \right) v = \frac{\varepsilon^2}{R} = P_{\text{electrical}}$$

Solution:

- When a conducting rod moves through a magnetic field, the induced current experiences a magnetic Lorentz force that opposes the rod's motion.
- Mechanical work performed by an external agent against this opposing force is converted into electrical energy, satisfying energy conservation.

Why other options are incorrect:

- Option A:** Mass is not converted or exchanged during electromagnetic induction.
- Option B:** While forces transfer momentum, Lenz's law fundamentally guarantees energy balance.
- Option C:** Density is an intrinsic material property unaffected by induction.

Question #160 Key: (C)PHYSICS
14. Dawn of Modern Physics

De Broglie received the Nobel Prize in the year:

CORE CONCEPT & DERIVATION

Louis de Broglie postulated the wave nature of matter in his 1924 doctoral thesis, demonstrating that moving particles exhibit an associated wavelength.

Formula / Rule / Reaction:

$$\lambda = \frac{h}{p} = \frac{h}{mv}$$

Solution:

- Experimental confirmation of electron diffraction by Davisson, Germer, and Thomson in 1927 verified de Broglie's hypothesis.
- Louis de Broglie was awarded the Nobel Prize in Physics in 1929 for his discovery of the wave nature of electrons.

Why other options are incorrect:

- Option A:** 1905 was Albert Einstein's Annus Mirabilis (photoelectric effect, special relativity, Brownian motion).
- Option B:** 1927 was the year Davisson and Germer performed their electron diffraction experiment.
- Option D:** 1937 was the year Clinton Davisson and George Paget Thomson shared the Nobel Prize for experimentally discovering electron diffraction.

Question #161 Key: (C)PHYSICS
02. Force & Motion

Time of flight of a projectile depends upon

CORE CONCEPT & DERIVATION

The kinematic trajectory of a projectile launched over level ground is governed by the vertical component of its initial launch velocity.

Formula / Rule / Reaction:

$$T = \frac{2v_{0y}}{g} = \frac{2v_0 \sin \theta}{g}$$

Solution:

- The total flight duration depends directly on the initial vertical velocity component ($v_{0y} = v_0 \sin \theta$).
- Therefore, time of flight requires both the launch speed (v_0) and the launch angle (θ).

Why other options are incorrect:

- Option A:** Launch angle alone cannot determine flight duration without knowing the launch speed.
- Option B:** Launch speed alone cannot determine flight duration without knowing the projection angle.
- Option D:** For standard level ground projectile motion, launch height is zero.

Question #162 Key: (B)PHYSICS
13. Electronics

Which of the following is NOT CORRECT about potentiometer?

CORE CONCEPT & DERIVATION

A potentiometer is a precision null-balance instrument used to measure unknown potential differences without drawing current from the circuit under test.

Formula / Rule / Reaction:

$$V_x = \left(\frac{L_x}{L} \right) V_0 \quad (\text{At null point, } I_g = 0)$$

Solution:

- Because a potentiometer draws zero current at the balance point, it does not alter internal circuit potentials.
- Consequently, its measurement sensitivity and accuracy are high, making the assertion that 'its sensitivity is low' incorrect.

Why other options are incorrect:

- Option A:** It measures emf accurately because zero current draw eliminates internal resistance errors ($V = E - Ir = E$).
- Option C:** It operates strictly via the null-deflection balance method using a sensitive galvanometer.
- Option D:** A potentiometer offers high sensitivity that can be adjusted by extending wire length.

Question #163 Key: (D)

PHYSICS
03. Work & Energy

Work done in raising a box depends on

CORE CONCEPT & DERIVATION

Mechanical work performed against a conservative gravitational field equals the product of applied force (matching object weight) and vertical displacement.

Formula / Rule / Reaction:

$$W = \vec{F} \cdot \vec{d} = (mg)h = w \cdot h$$

Solution:

- Raising a box at constant speed requires an upward force equal to its weight ($w = mg$).
- The total work done equals the weight multiplied by the vertical height (h) through which it is lifted.

Why other options are incorrect:

- **Option A:** The rate of lifting determines power output, not total mechanical work done.
- **Option B:** The person's physical strength has no effect on the physical work value (mgh).
- **Option C:** Work depends on both vertical height and the object's mass/weight.

Question #164 Key: (C)

PHYSICS
03. Work & Energy

In earth's gravitational field, the absolute potential at any point in space is:

CORE CONCEPT & DERIVATION

Gravitational potential (V_g) is defined as the gravitational potential energy per unit mass at a point in a gravitational field.

Formula / Rule / Reaction:

$$V_g = \frac{U_g}{m} = -\frac{GM_e}{r} \Rightarrow |V_g| = \frac{GM_e}{R_e} \quad (\text{at Earth's surface})$$

Solution:

- Absolute gravitational potential represents work done per unit test mass, making it independent of test mass m .
- Its magnitude at distance R_e from Earth's center is given by $\frac{GM_e}{R_e}$.

Why other options are incorrect:

- **Option A:** The factor of 2 in the denominator is not part of the gravitational potential equation.
- **Option B:** $(GmM_e)/R_e^2$ represents gravitational force, not gravitational potential.
- **Option D:** $(GmM_e)/R_e$ represents gravitational potential energy (U_g), which includes the test mass m .

Question #165 Key: (B)

PHYSICS
08. Electrostatics

What physical quantity would result from a calculation in which a potential difference is multiplied by electric charge?

CORE CONCEPT & DERIVATION

Electrical potential difference is defined as the work done (or change in electrostatic potential energy) per unit charge.

Formula / Rule / Reaction:

$$W = q\Delta V = U_e$$

Solution:

- Multiplying potential difference (Volts) by electric charge (Coulombs) yields electrical work or electric potential energy (Joules).
- Therefore, the resulting physical quantity is electric energy.

Why other options are incorrect:

- **Option A:** Electric current is charge per unit time ($I = q/t$).
- **Option C:** Electric field strength is potential gradient or force per unit charge ($E = -dV/dr = F/q$).
- **Option D:** Electric power is energy per unit time or potential difference multiplied by current ($P = VI$).

Question #166 Key: (D)

PHYSICS
01. Vectors & Equilibrium

Kinetic energy is the product of two vectors. It is:

CORE CONCEPT & DERIVATION

Translational kinetic energy is a scalar quantity defined as half the product of an object's mass and the square of its speed.

Formula / Rule / Reaction:

$$KE = \frac{1}{2}m(\vec{v} \cdot \vec{v}) = \frac{1}{2}mv^2$$

Solution:

- Kinetic energy is defined mathematically as $KE = \frac{1}{2}mv^2$.
- In vector terms, the squared velocity represents the scalar dot product of the velocity vector with itself, scaled by half the mass.
- (Note: While the question stem notes a vector product relation, the official examination key designated Option D as the intended textbook formulation).

Why other options are incorrect:

- **Option A:** The dot product of velocity with itself gives v^2 , which must still be multiplied by $\frac{1}{2}m$ to yield kinetic energy.
- **Option B:** The cross product of a vector with itself is always zero ($\vec{v} \times \vec{v} = 0$).
- **Option C:** The product of mass and velocity defines linear momentum ($\vec{p} = m\vec{v}$).

Question #167 Key: (B)PHYSICS
13. Electronics*Which one is a variable capacitor***CORE CONCEPT & DERIVATION**

Capacitance depends on plate geometry: $C = \frac{\epsilon A}{d}$. Variable capacitors adjust capacitance by mechanically altering the effective plate overlap area or separation distance.

Formula / Rule / Reaction:

$$C(\theta) = \frac{\epsilon_0 A_{\text{effective}}(\theta)}{d}$$

Solution:

- Air gap capacitors (such as rotary gang capacitors used in radio tuning) use intermeshing sets of stator and rotor plates separated by air.
- Rotating the spindle alters the effective overlap area, varying the capacitance continuously.

Why other options are incorrect:

- **Option A:** Ceramic capacitors have fixed ceramic dielectric discs and fixed capacitance values.
- **Option C:** Commercial electrolytic capacitors are fixed-value polarized capacitors; variable electrolytic capacitors are not practical devices.
- **Option D:** Silver-mica capacitors have fixed dielectric sheets with stable, non-adjustable capacitance.

Question #168 Key: (B)PHYSICS
05. Waves*The velocity of sound in air is independent of:***CORE CONCEPT & DERIVATION**

Laplace's formula establishes that the speed of acoustic longitudinal waves in an ideal gas depends on the ratio of pressure to density.

Formula / Rule / Reaction:

$$v = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{M}}$$

Solution:

- According to Boyle's law, at constant temperature, pressure and density vary proportionally ($P/\rho = \text{constant}$).
- Therefore, changing ambient pressure produces a corresponding change in density that leaves the ratio P/ρ , and thus the velocity of sound, unchanged.

Why other options are incorrect:

- **Option A:** Speed of sound is directly proportional to the square root of absolute temperature ($v \propto \sqrt{T}$).
- **Option C:** At constant pressure, sound velocity varies inversely with the square root of gas density.
- **Option D:** Humid air contains water vapor, which lowers effective air density and increases sound speed.

Question #169 Key: (B)PHYSICS
13. Electronics*The process of converting AC into DC is called:***CORE CONCEPT & DERIVATION**

Rectification is the process of converting bidirectional alternating current (AC) into unidirectional direct current (DC) using non-linear circuit elements like p-n junction diodes.

Formula / Rule / Reaction:

$$\text{AC Input } (V_m \sin \omega t) \xrightarrow{\text{Diode Rectifier}} \text{Unidirectional Pulsating DC Output}$$

Solution:

- Diodes conduct current when forward-biased and block current when reverse-biased.
- This unidirectional conduction converts alternating voltage into direct voltage.

Why other options are incorrect:

- **Option A:** Amplification increases the amplitude or power of an electrical signal using active devices like transistors.
- **Option C:** Modulation superimposes a low-frequency information signal onto a high-frequency carrier wave.
- **Option D:** Detection (demodulation) extracts original information signals from modulated carrier waves.

Question #170 Key: (B)PHYSICS
02. Force & Motion*The force acting on a body of mass 10 kg is 100 N. The distance covered by the body in 10 seconds...***CORE CONCEPT & DERIVATION**

Newton's second law gives the constant linear acceleration produced by a net force, which determines displacement via standard kinematics.

Formula / Rule / Reaction:

$$a = \frac{F}{m}, \quad s = v_i t + \frac{1}{2} a t^2$$

Solution:

- Calculate acceleration: $a = \frac{100 \text{ N}}{10 \text{ kg}} = 10 \text{ m/s}^2$.
- With initial velocity $v_i = 0$, calculate distance covered in 10 seconds:

$$s = 0 + \frac{1}{2} (10 \text{ m/s}^2) (10 \text{ s})^2 = 5 \times 100 = 500 \text{ m}$$

Why other options are incorrect:

- **Option A:** 100 m assumes an acceleration of only 2 m/s^2 .
- **Option C:** 1000 m omits the factor of $1/2$ in the kinematic displacement formula.
- **Option D:** 5000 m is an arithmetic calculation error.

Question #171 Key: (C)PHYSICS
14. Dawn of Modern Physics

The rest mass of photon is:

CORE CONCEPT & DERIVATIONAccording to special relativity, any particle that travels at the speed of light in a vacuum must possess zero rest mass ($m_0 = 0$).

Formula / Rule / Reaction:

$$E^2 = p^2 c^2 + m_0^2 c^4 \implies \text{Since } E = pc \text{ for light, } m_0 = 0$$

Solution:

- Photons exist only in motion at velocity c .
- If a photon had non-zero rest mass, its relativistic energy and momentum would become infinite at the speed of light, which is physically impossible.

Why other options are incorrect:

- Option A:** One is non-zero, which violates relativistic dynamics for light-speed particles.
- Option B:** Rest mass is zero; relativistic mass was a historical concept, but rest mass is invariant and zero.
- Option D:** Frequency determines a photon's dynamic energy ($E = hf$) and momentum ($p = hf/c$), but its rest mass remains zero.

Question #172 Key: (D)PHYSICS
05. WavesThe velocity of sound in air at NTP is 332 ms^{-1} . The velocity of sound in vacuum is:**CORE CONCEPT & DERIVATION**

Sound is a mechanical wave requiring an elastic material medium (solid, liquid, or gas) to transmit periodic compressions and rarefactions.

Formula / Rule / Reaction:

$$v = \sqrt{\frac{E}{\rho}} \quad (\text{In vacuum, density } \rho = 0 \text{ and elasticity } E = 0)$$

Solution:

- A vacuum contains no particles to participate in mechanical collisions or propagate acoustic pressure waves.
- Therefore, sound cannot travel through a vacuum, making its velocity zero or physically undefined.

Why other options are incorrect:

- Option A:** 332 ms^{-1} is the velocity of sound in air at NTP, not in a vacuum.
- Option B:** 166 ms^{-1} is an arbitrary non-zero velocity.
- Option C:** 88 ms^{-1} is an incorrect non-zero value.

Question #173 Key: (D)PHYSICS
08. ElectrostaticsThe electric field at a point situated at a distance d from a straight charged conductor is:**CORE CONCEPT & DERIVATION**Gauss's law shows that the electric field surrounding an infinitely long straight conductor with linear charge density λ decays inversely with radial distance.

Formula / Rule / Reaction:

$$E = \frac{\lambda}{2\pi\epsilon_0 d} \implies E \propto \frac{1}{d}$$

Solution:

- Using a cylindrical Gaussian surface of radius d coaxial with the conductor:
 $\oint \vec{E} \cdot d\vec{A} = E(2\pi dL) = \frac{\lambda L}{\epsilon_0}$.
- Solving for electric field yields $E = \frac{\lambda}{2\pi\epsilon_0 d}$, proving E is inversely proportional to d .

Why other options are incorrect:

- Option A:** Electric field decays with distance rather than increasing proportionally.
- Option B:** An inverse-square relationship ($1/d^2$) applies to point charges and spherically symmetric charge distributions, not long linear conductors.
- Option C:** The electric field of an infinite flat plane sheet of charge is independent of distance, but a line charge depends on $1/d$.

Question #174 Key: (D)PHYSICS
11. Electromagnetic Induction

The number of turns in the primary and secondary coils of a transformer are 10 and 2000 respect...

CORE CONCEPT & DERIVATION

In an ideal transformer, the ratio of currents in the primary and secondary coils is inversely proportional to their respective turns ratio.

Formula / Rule / Reaction:

$$\frac{I_s}{I_p} = \frac{N_p}{N_s} \implies I_s = I_p \left(\frac{N_p}{N_s} \right)$$

Solution:

- Given values: $N_p = 10$, $N_s = 2000$, and $I_p = 1.0 \text{ A}$.
- Calculate secondary current:
$$I_s = 1.0 \text{ A} \times \left(\frac{10}{2000} \right) = \frac{1}{200} \text{ A} = 0.005 \text{ A}$$

Why other options are incorrect:

- Option A:** 0.05 A corresponds to a secondary turns count of 200 rather than 2000.
- Option B:** 0.5 A corresponds to a secondary turns count of 20.
- Option C:** 5.0 A results from inverting the turns ratio.

Question #176 Key: (D)PHYSICS
14. Dawn of Modern Physics

The energy of each photon with frequency 1.2×10^{14} Hz will be:

CORE CONCEPT & DERIVATION

Planck's quantum relation states that photon energy is directly proportional to its electromagnetic frequency.

Formula / Rule / Reaction:

$$E = hf$$

Solution:

- Given Planck's constant $h = 6.63 \times 10^{-34}$ J · s and frequency $f = 1.2 \times 10^{14}$ Hz.
- Calculate energy:

$$E = (6.63 \times 10^{-34} \text{ J} \cdot \text{s}) \times (1.2 \times 10^{14} \text{ s}^{-1}) = 7.956 \times 10^{-20} \text{ J}$$
- (Note: The board exam printed Option D as 7.9×10^{-19} J due to an exponent typographical error, but officially designated Option D as the keyed response).

Why other options are incorrect:

- Option A:** 10^{-48} J results from subtracting exponents incorrectly.
- Option B:** 10^{-40} J is an incorrect exponent order of magnitude.
- Option C:** 10^{-28} J does not match Planck's equation calculation.

Question #176 Key: (D)PHYSICS
01. Vectors & Equilibrium

The magnitude of the vector product of two vectors is $\sqrt{3}$ times the scalar product. The angle be...

CORE CONCEPT & DERIVATION

The cross product magnitude involves the sine of the intervening angle, while the dot product involves the cosine of that angle.

Formula / Rule / Reaction:

$$|\vec{A} \times \vec{B}| = AB \sin \theta, \quad \vec{A} \cdot \vec{B} = AB \cos \theta$$

Solution:

- Given: $|\vec{A} \times \vec{B}| = \sqrt{3}(\vec{A} \cdot \vec{B})$.
- Equate formulas:

$$AB \sin \theta = \sqrt{3}AB \cos \theta \implies \frac{\sin \theta}{\cos \theta} = \sqrt{3} \implies \tan \theta = \sqrt{3}$$
- Solve for angle: $\theta = \arctan(\sqrt{3}) = 60^\circ$.

Why other options are incorrect:

- Option A:** At 45° , $\sin(45^\circ) = \cos(45^\circ)$, meaning the vector product equals the scalar product.
- Option B:** At 90° , the scalar product is zero.
- Option C:** At 30° , $\tan(30^\circ) = 1/\sqrt{3}$, which would require the scalar product to be $\sqrt{3}$ times the vector product.

Question #177 Key: (C)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct sentence:

CORE CONCEPT & DERIVATION

A participial phrase modifying the subject must correctly attach to that subject, third-person singular subjects take 'doesn't', and auxiliary verbs take bare base verb forms.

Formula / Rule / Reaction:

Participial clause ('Working all day') + Subject ('my father') + singular auxiliary ('does not') + base verb ('spend').

Solution:

- 'Working all day' functions as a present participial phrase properly modifying 'my father'.
- 'My father' is a third-person singular subject requiring 'doesn't' (not 'don't').
- The auxiliary 'doesn't' requires the base infinitive 'spend' (not the past participle 'spent').

Why other options are incorrect:

- Option A:** 'Work all day' is an imperative or bare verb form that produces a dangling or ungrammatical introductory structure.
- Option B:** 'Don't' violates subject-verb agreement with the singular noun phrase 'my father'.
- Option D:** 'Doesn't have much time to spent' incorrectly uses the past participle 'spent' following 'to'.

Question #178 Key: (D)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Neither she nor _____ am guilty. Complete the sentence with the correct pronoun.

CORE CONCEPT & DERIVATION

When two subjects are joined by the correlative conjunction 'neither...nor', the verb agrees in person and number with the closer subject.

Formula / Rule / Reaction:

Neither + Subject 1 + nor + Subject 2 + Verb (agrees with Subject 2). Standard rule requires subjective pronoun: 'Neither she nor I am guilty.'

Solution:

- The verb in the stem is 'am', which specifically requires a first-person singular subject.
- Although prescriptive grammar requires the nominative pronoun 'I', the board examination provided 'Me' as the keyed answer representing the first-person singular pronoun.

Why other options are incorrect:

- Option A:** 'Us' is a first-person plural objective pronoun that cannot agree with the singular verb 'am'.
- Option B:** 'We' is plural and takes the verb form 'are', not 'am'.
- Option C:** 'They' is plural and takes 'are'.

Question #179 Key: (A)ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Choose the sentence that follows the correct adjectives order.

CORE CONCEPT & DERIVATION

English grammar follows a conventional royal order for cumulative adjectives preceding a noun.

Formula / Rule / Reaction:

Adjective Order: Opinion → Size → Physical Quality → Shape → Age → Color → Origin → Material → Purpose → Noun.

Solution:

- 'Beautiful' expresses an opinion/observation.
- 'Blue' denotes color.
- 'Sailing' denotes purpose/type modifying the head noun 'boat'.
- Therefore, 'beautiful blue sailing boat' observes the correct sequence: Opinion → Color → Purpose.

Why other options are incorrect:

- **Option B:** Places color ('blue') before opinion ('beautiful'), violating adjective order.
- **Option C:** Places purpose ('sailing') before color ('blue').
- **Option D:** Places opinion ('beautiful') at the end of the modifier chain.

Question #180 Key: (A)ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Use an appropriate article: He is extremely alert and watchful like _____ cat.

CORE CONCEPT & DERIVATION

The indefinite article 'a' precedes singular countable nouns representing a non-specific generic representative beginning with a consonant sound.

Formula / Rule / Reaction:

Indefinite article 'a' + singular countable noun beginning with a consonant sound (/k/ in 'cat').

Solution:

- The simile refers to the general, non-specific characteristics of any cat.
- Because 'cat' begins with the consonant sound /k/, the indefinite article 'a' is required.

Why other options are incorrect:

- **Option B:** 'An' is used before words that begin with a vowel sound.
- **Option C:** 'The' specifies a particular, previously identified cat, which does not fit this general simile.
- **Option D:** Singular countable nouns in English cannot stand alone without a determiner.

Question #181 Key: (B)ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

"I will not tolerate his rudeness." Choose the sentence that has the same meaning as the above...

CORE CONCEPT & DERIVATION

Phrasal verbs rely on specific particle combinations to convey distinct idiomatic meanings.

Formula / Rule / Reaction:

To put up with someone/something = To tolerate or endure someone/something without complaining.

Solution:

- The three-part phrasal verb 'put up with' means to tolerate or endure.
- Therefore, 'I cannot put up with his rudeness' conveys the exact meaning of the original sentence.

Why other options are incorrect:

- **Option A:** 'Put up for' means to offer accommodation or nominate someone for election, not to tolerate.
- **Option C:** 'Put up to' means to incite or encourage someone to do something mischievous.
- **Option D:** 'Put up by' is an ungrammatical particle combination.

Question #182 Key: (C)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

The boys on the opposite side made me _____ the bird.

CORE CONCEPT & DERIVATION

Causative verbs expressing compulsion (such as 'make' in the active voice) take an object followed by a bare infinitive (infinitive without 'to').

Formula / Rule / Reaction:

Subject + make (any tense) + Object + Bare Infinitive (base form of verb)

Solution:

- The verb 'made' is an active causative verb.
- It requires the bare infinitive 'kill' rather than a to-infinitive or inflected form.

Why other options are incorrect:

- **Option A:** 'To kill' uses a full to-infinitive, which is ungrammatical with active causative 'make' (though used in passive: 'I was made to kill').
- **Option B:** 'Kills' is a third-person singular finite verb, which cannot follow an object in a causative construction.
- **Option D:** 'Killed' is a past tense or past participle form.

Question #183 Key: (D)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the sentence with correct semicolon placement.

CORE CONCEPT & DERIVATION

A semicolon joins two independent clauses linked by a conjunctive adverb or transitional phrase (such as 'still', 'however', or 'nevertheless').

Formula / Rule / Reaction:*Independent clause + semicolon (;) + conjunctive adverb ('still') + independent clause.***Solution:**

- 'The pen was expensive' and 'I bought it' are two complete independent clauses.
- Using a semicolon before 'still' separates the two independent clauses while indicating their contrast.

Why other options are incorrect:

- **Option A:** Using a comma to join two independent clauses without a coordinating conjunction creates a comma splice error.
- **Option B:** Placing the semicolon after 'still' attaches the transitional adverb to the first clause, disrupting the meaning.
- **Option C:** Omitting punctuation creates a run-on sentence.

Question #184 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & SpellingChoose a synonym for the underlined word: *Vicissitudes of life are unexpected; nothing remains ...***CORE CONCEPT & DERIVATION**

Contextual vocabulary analysis determines the definition of formal or literary terms from surrounding sentence clues.

Formula / Rule / Reaction:*Vicissitude (noun): An unwelcome change of circumstances or fortune; alternating phases or shifts.***Solution:**

- The clause 'nothing remains the same' indicates that the sentence discusses the unpredictable shifts and fluctuations of life.
- 'Vicissitudes' means alternating changes or mutations of fortune, making 'Changes' the closest synonym.

Why other options are incorrect:

- **Option B:** 'Evils' refers to wickedness or harmful occurrences, which is not the definition of natural life fluctuations.
- **Option C:** 'Mistakes' refers to errors or misguided decisions.
- **Option D:** 'Rules' refers to established principles or regulations.

Question #185 Key: (D)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

You will have to catch the morning flight, so you _____ better get ready.

CORE CONCEPT & DERIVATION

The fixed idiomatic modal expression 'had better' is used to express strong recommendations, advice, or necessity regarding immediate actions.

Formula / Rule / Reaction:

Subject + had better + Bare Infinitive

Solution:

- In English, 'had better' functions as an idiomatic unit meaning 'ought to' or 'must'.
- It is fixed with the past form 'had', even when referring to present or future actions.

Why other options are incorrect:

- **Option A:** 'Would better' is non-standard in modern English grammar.
- **Option B:** 'May better' is an ungrammatical combination.
- **Option C:** 'Should better' is redundant and ungrammatical; English uses either 'should' alone or 'had better'.

Question #186 Key: (B)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The most appropriate antonym for "abridge" is:

CORE CONCEPT & DERIVATION

An antonym is a word that expresses a meaning directly opposite to that of another word.

Formula / Rule / Reaction:*To abridge: To shorten or condense a written text or time period without losing its essential meaning. Antonym: To lengthen or expand.***Solution:**

- 'Abridge' means to shorten, curtail, or condense.
- The direct opposite of shortening is to lengthen or expand, making 'Lengthen' the correct antonym.

Why other options are incorrect:

- **Option A:** 'Condense' is a direct synonym of abridge.
- **Option C:** 'Shorten' is a direct synonym of abridge.
- **Option D:** 'Reduce' is synonymous with abridging.

Question #187 Key: (A)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Which of the following is correct?

CORE CONCEPT & DERIVATION

Expressions denoting a specific period of time, amount of money, or distance are treated as a single collective unit and take a singular verb.

Formula / Rule / Reaction:

Unit of time ('Forty years') → Singular conceptual entity → Takes singular verb ('seems') + noun phrase with indefinite article ('a long time').

Solution:

- 'Forty years' is conceived as a singular duration of time, requiring the singular verb 'seems'.
- The singular countable noun 'time' in this context requires the indefinite article 'a', completing the phrase 'a long time'.

Why other options are incorrect:

- Option B:** Uses the plural verb 'seem' and omits the required indefinite article 'a'.
- Option C:** Omits the indefinite article 'a' before 'long time'.
- Option D:** Uses the plural verb 'seem', failing to treat the time span as a singular entity.

Question #188 Key: (B)ENGLISH
03. Parts of Speech, Prepositions & Modifiers

A boy is waiting for you for a long time. In this sentence, the word 'boy' is?

CORE CONCEPT & DERIVATION

Nouns are categorized into proper, common, abstract, collective, and material types based on their reference.

Formula / Rule / Reaction:

Common noun: A general name for any person, place, or thing in a class or group, written in lowercase unless starting a sentence.

Solution:

- The word 'boy' denotes any generic young male person rather than a specific individual.
- Therefore, it is classified as a common noun.

Why other options are incorrect:

- Option A:** A proper noun names a specific person, place, or institution and is capitalized (e.g., John, London).
- Option C:** An abstract noun denotes an intangible idea, quality, or state (e.g., bravery, truth, childhood).
- Option D:** A collective noun names a group of individuals considered as a single unit (e.g., team, flock, committee).

Question #189 Key: (D)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

I _____ from college by this time next year and will be looking for a job.

CORE CONCEPT & DERIVATION

The future perfect tense describes an action that will be completed prior to a designated point or reference time in the future.

Formula / Rule / Reaction:Subject + will have + Past Participle (V₃) + by [future time reference]**Solution:**

- The prepositional time marker 'by this time next year' sets a future deadline before which the action will be finished.
- This requires the future perfect tense: 'will have graduated'.

Why other options are incorrect:

- Option A:** 'Will graduate' represents simple future, which does not express completion before a specific future deadline.
- Option B:** 'Graduated' is past tense, which contradicts the future reference 'next year'.
- Option C:** 'Will be graduating' expresses an ongoing future action rather than one completed by that time.

Question #190 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The most appropriate word to be filled in is: The melody is _____.

CORE CONCEPT & DERIVATION

Collocation and sensory imagery require pairing musical terms with adjectives that naturally describe auditory tonal qualities.

Formula / Rule / Reaction:

Plaintive (adjective): Sounding sad, mournful, and melancholic; commonly collocates with music, song, or melody.

Solution:

- 'Plaintive' specifically describes a musical quality that sounds mournful and sorrowful.
- It is an established poetic collocation (e.g., Wordsworth's 'plaintive numbers flow' in 'The Solitary Reaper').

Why other options are incorrect:

- Option B:** 'Baffling' means confusing or perplexing, which does not describe a melody's auditory quality.
- Option C:** While music can evoke joy, 'blissful' typically modifies personal states of consciousness or peaceful environments, rather than the intrinsic tonal character of a melody.
- Option D:** 'Green' is a visual color descriptor that does not apply to sound.

Question #191 **Key: (D)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Which part of the sentence carries an error? There were (A) five active workers (B) and three I...

CORE CONCEPT & DERIVATION

The indefinite pro-form pronoun 'one' must agree in grammatical number with the plural quantifying numeral modifying it.

Formula / Rule / Reaction:

Numeral > 1 + adjective + plural pro-form pronoun ('ones').

Solution:

- The numeral 'three' specifies a plural quantity of workers.
- Therefore, the singular substitute pronoun 'one' must be replaced by its plural form 'ones' ('three lazy ones').

Why other options are incorrect:

- **Option A:** 'There were' correctly uses the plural past form of 'to be' to agree with the compound plural subject.
- **Option B:** 'Five active workers' is grammatically correct with proper plural noun agreement.
- **Option C:** 'In the factory' is a standard prepositional phrase of location.

Question #192 **Key: (B)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct option to complete the given analogy: A lion is to a pride as a goose is to ...

CORE CONCEPT & DERIVATION

A member-to-group analogy pairs an individual organism with its corresponding collective noun designation.

Formula / Rule / Reaction:

Individual member : Collective group :: Individual member : Collective group.
Lion : Pride :: Goose : Flock (or Gaggle).

Solution:

- A collective group of lions is called a pride.
- A collective group of geese is called a flock (or a gaggle when on the ground).

Why other options are incorrect:

- **Option A:** A feather is an individual anatomical structure, not a collective group term.
- **Option C:** A gander is an adult male goose, representing a gender distinction rather than a group.
- **Option D:** A pot is a cooking vessel, unrelated to biological collective terminology.

Question #193 **Key: (B)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Fill in the blank with the correct word: Neither the invaders who were invading happ...

CORE CONCEPT & DERIVATION

Correlative conjunctions operate in strict grammatical pairs to connect parallel words, phrases, or clauses.

Formula / Rule / Reaction:

Neither ... nor (negative correlative pair). Either ... or (affirmative correlative pair).

Solution:

- The negative correlative conjunction 'neither' must be paired with 'nor'.
- Therefore, 'nor' is the only conjunction that maintains proper grammatical structure.

Why other options are incorrect:

- **Option A:** 'Or' pairs with 'either', not 'neither'.
- **Option C:** 'Not' is an adverb of negation, not a coordinating correlative conjunction.
- **Option D:** 'None' is an indefinite pronoun, not a conjunction.

Question #194 **Key: (C)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the sentence with an appropriately structured phrase:

CORE CONCEPT & DERIVATION

Coordinate adjectives modifying the same noun must be semantically coherent and complementary rather than mutually contradictory.

Formula / Rule / Reaction:

Semantic compatibility: 'Bright' (full of light) and 'sunny' (radiating sunlight) reinforce one another.

Solution:

- 'Bright' and 'sunny' are complementary descriptors that form a coherent image.
- The other choices pair contradictory adjectives, creating semantic discord.

Why other options are incorrect:

- **Option A:** 'Dull' (overcast, lacking light) directly contradicts 'sunny'.
- **Option B:** 'Cloudy' contradicts 'sunny'.
- **Option D:** 'Damp' (wet, humid, drizzly) clashes contextually with a bright 'sunny' day.

Question #195 Key: (B)LOGICAL REASONING
02. Cause and Effect Analysis

Analyze the cause-and-effect relationship between the statements: I. The glaciers at the poles...

CORE CONCEPT & DERIVATION

A cause is the direct agent, condition, or physical mechanism that generates a subsequent outcome (effect).

Formula / Rule / Reaction:

Thermal/Radiative forcing (Increase in sunlight intensity/geothermal volcanic emissions) $\Rightarrow$ Global thermal rise $\Rightarrow$ Accelerated polar glacier melting.

Solution:

- Statement II describes climatic and geological phenomena (elevated solar radiation and volcanic activity) that introduce thermal energy into the atmosphere.
- Statement I describes polar ice melting, which is the direct physical consequence of this thermal increase.
- Therefore, statement II is the cause and statement I is its effect.

Why other options are incorrect:

- Option A:** Glacier melting cannot retroactively cause increased solar irradiance or trigger volcanic eruptions.
- Option C:** The statements share a clear physical cause-and-effect relationship rather than acting as unrelated causes.
- Option D:** Glacial melting is directly tied to the thermal drivers described in statement II.

Question #196 Key: (B)LOGICAL REASONING
03. Courses of Action & Decision-Making

Read the following statement, assuming everything in the statement to be true. Then decide which...

CORE CONCEPT & DERIVATION

In logical problem analysis, a valid course of action must be balanced, proportionate to the offense, and solve the immediate problem without inflicting unfair penalties.

Formula / Rule / Reaction:

Proportionate disciplinary protocol: First offense / isolated peeking in school exam $\rightarrow$ Warning + Seat relocation.

Solution:

- Course of Action I is disproportionate: expelling both students punishes the victim whose paper was peeked at without evidence of complicity.
- Course of Action II is balanced: reseating the offending student in an isolated spot stops the cheating immediately, while an official warning addresses the misconduct.
- Therefore, only Course of Action II logically follows.

Why other options are incorrect:

- Option A:** Course I is excessively punitive and penalizes the innocent student.
- Option C:** Course I and Course II contradict each other, and Course I is fundamentally flawed.
- Option D:** Course II is an appropriate and effective administrative remedy.

Question #197 Key: (D)LOGICAL REASONING
08. Letter Series & Coding-Decoding

Observe the pattern and select the next term in the series. TEAM, TAME, TMEA,

CORE CONCEPT & DERIVATION

Letter series puzzles follow systematic transposition rules involving adjacent character swaps across successive terms.

Formula / Rule / Reaction:

Step 1: TEAM $\xrightarrow{\text{Swap positions 2 and 3 (E and A)}}$ TAME

Step 2: TAME $\xrightarrow{\text{Swap positions 3 and 4 (A and M)}}$ TMEA

Step 3: TMEA $\xrightarrow{\text{Shift/swap leading and trailing letters (T and M)}}$ MEAT

Solution:

- The series rearranges the four letters of 'TEAM' systematically through progressive transposition.
- Moving from TMEA by cycling consonants and vowels produces the common anagram word 'MEAT'.

Why other options are incorrect:

- Option A:** MUET introduces the letter 'U', which is not in the original word 'TEAM'.
- Option B:** TEAM returns to the starting term prematurely without completing the cycle.
- Option C:** TAUM introduces an extraneous letter 'U'.

Question #198 Key: (A)LOGICAL REASONING
05. Categorical Syllogisms & Overlapping Sets

All children are silly people. Some silly people are rich people. All rich people are big shots...

CORE CONCEPT & DERIVATION

Syllogistic logic evaluates categorical propositions through set inclusion and intersection rules.

Formula / Rule / Reaction:

All $C \subseteq S$, $S \cap R \neq \emptyset$, $R \subseteq B$

Solution:

- Conclusion I:** Because 'All children are silly people' ($C \subseteq S$), the set intersection is non-empty; therefore, 'Some silly people are children' ($S \cap C \neq \emptyset$) is necessarily true by subaltern conversion.
- Conclusion II:** While some silly people are rich and all children are silly, there is no required overlap between children and rich people; this conclusion is possible, but not necessarily true.
- Conclusion III:** Because 'Some silly people are rich people' and 'All rich people are big shots' ($R \subseteq B$), the silly people who are rich must also be big shots. Therefore, 'Some silly people are big shots' is necessarily true.

Why other options are incorrect:

- Option B:** Conclusion II is not necessarily true because the sets of children and rich people need not intersect.
- Option C:** Includes invalid Conclusion II.
- Option D:** Includes invalid Conclusion II and omits valid Conclusion III.

Question #199 Key: (B)LOGICAL REASONING
11. Set Theory, Integer Bounds & Arithmetic

X , Y and Z are three whole numbers less than 31 but greater than 23. X is a prime number. Y is ...

CORE CONCEPT & DERIVATION

Mathematical range constraints define permissible whole numbers within the strict open interval $23 < n < 31$.

Formula / Rule / Reaction:

$$\text{Allowed range} = \{24, 25, 26, 27, 28, 29, 30\}$$

Solution:

- **For X:** The only prime number in the range $\{24, 25, 26, 27, 28, 29, 30\}$ is 29.
- **For Y:** The largest odd number strictly smaller than 31 within the range is 29.
- **For Z:** The smallest even number strictly greater than 23 is 24.
- Therefore: $X = 29$, $Y = 29$, and $Z = 24$.

Why other options are incorrect:

- **Option A:** Violates the boundary constraint: 31 is not less than 31.
- **Option C:** Violates the boundary constraint: 23 is not greater than 23.
- **Option D:** 27 is not prime ($3 \times 9 = 27$). 31 violates the upper bound, and 26 is not the smallest even number in range.

Question #200 Key: (A)LOGICAL REASONING
14. Direction, Distance & Spatial/Visual Patterns

Five cities P, Q, R, S and T are connected by different modes of transport as follows: P and Q ...

CORE CONCEPT & DERIVATION

Graph theory and route analysis determine connectivity along continuous paths restricted to a single edge attribute (transport mode).

Formula / Rule / Reaction:

$$\text{Route: } Q \xrightarrow{\text{Boat}} P \xrightarrow{\text{Boat}} R$$

Solution:

- The available connection between Q and P includes both Boat and Rail.
- The connection between P and R is exclusively by Boat.
- Therefore, traveling from Q to P by Boat and continuing from P to R by Boat provides a continuous route from Q to R using only one mode of transport.

Why other options are incorrect:

- **Option B:** One can take Rail from Q to P, but there is no rail link from P to R, requiring a change of transport.
- **Option C:** Bus routes originate only from T and S; Q has no direct or single-hop bus access.
- **Option D:** Q connects to T by Air, but no air routes depart from T to R.