

**BEAMBEPREP**

PAKISTAN ENTRANCE EXAMINATION ENGINE

**SCAN TO SOLVE LIVE**Timer, instant scoring, and
percentile ranks on
beambeprep.com

UHS LAHORE

UHS Lahore MDCAT 2023 Official Paper

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

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

Which of the following is the main point of Darwinism?

- (A) Snake's legs
- (B) Natural selection
- (C) Muscle atrophy
- (D) Movement of ear

Q2. BIO

According to evolutionary studies, prokaryotes may have arisen around:

- (A) 2.5 billion years ago
- (B) 3.5 billion years ago
- (C) 4.5 billion years ago
- (D) 5.5 billion years ago

Q3. BIO

The enzyme which can work on pH 7 of the medium is:

- (A) Pepsin
- (B) Sucrase
- (C) Pancreatic lipase
- (D) Chymotrypsin

Q4. BIO

Which enzyme is different from others?

- (A) Pepsin
- (B) Trypsin
- (C) Chymotrypsin
- (D) Lactase

Q5. BIO

Competitive inhibitors are:

- (A) Homologous to substrate
- (B) Analogous to substrate
- (C) Smaller than substrate
- (D) Larger than substrate

Q6. BIO

The active sites of enzymes are composed of:

- (A) Few Nucleotides
- (B) Few Nucleosides
- (C) Few Saccharides
- (D) Few Amino Acids

Q7. BIO

NAD is an important:

- (A) Enzyme
- (B) Coenzyme
- (C) Hormone
- (D) Vitamin

Q8. BIO

What is true about oxytocin?

- (A) Acts on kidney tubules
- (B) Stimulates ICSH
- (C) Perform cellular functions
- (D) Dilate milk ducts of mammary glands

Q9. BIO

In a typical nerve, the action potential duration is:

- (A) 1 millisecond
- (B) 1 microsecond
- (C) 1 second
- (D) 1 minute

Q10. BIO

During resting membrane potential condition:

- (A) Outer surface of neuron is more positive
- (B) Inner surface of neuron is more positive
- (C) Both of these surfaces are equally positive
- (D) Both of these surfaces are equally negative

Q11. BIO

The value of the active membrane potential of the neuron is:

- (A) 0.01 volts
- (B) 0.02 volts
- (C) 0.05 volts
- (D) 0.07 volts

Q12. BIO

The chemical messengers that transmit action potential across the synapse in the form of chemicals are:

- (A) Synaptic knob of synapse
- (B) Reflex actions
- (C) Neurotransmitters
- (D) Acetylcholinesterase

Q13. BIO

The pressure receptors that receive deep pressure stimulus in the human body are called:

- (A) Meissner Corpuscles
- (B) Pacinian Corpuscles
- (C) Red Blood Corpuscles
- (D) Cholesterol

Q14. BIO

Cells of different types can be distinguished on the basis of surface:

- (A) Phospholipids
- (B) Globular proteins
- (C) Glycolipids and glycoproteins
- (D) Cholesterol

Q15. BIO

Mitosis, a type of cell division, is observed in:

- (A) E. Coli
- (B) Nostoc
- (C) Cyanobacteria
- (D) None of these

Q16. BIO

Which of the following types of organs are supposed to be functional in ancestral species rather than in present-day species?

- (A) Vestigial organs
- (B) Homologous organs
- (C) Analogous organs
- (D) Embryonic organs

Q17. BIO

The descending aorta is bifurcated into two vessels, which further divide into the femoral artery that supplies blood to the thigh muscles of the legs:

- (A) iliac vein
- (B) iliac artery
- (C) temporal artery
- (D) Sciatic artery

Q18. BIO

The final destination of lymph is:

- (A) Lymph Nodes
- (B) Lymphoid organs
- (C) Lymph capillaries
- (D) Subclavian vein

Q19. BIO

The ABO blood group is controlled by more than two alleles in a population. This shows that the ABO blood group is an example of:

- (A) Polygenic Inheritance
- (B) Multiple Alleles
- (C) Operons
- (D) Allelic interaction

Q20. BIO

According to Mendel's Law of Segregation, one individual out of four in the F2 generation had a phenotype that failed to express in the generation:

- (A) F1
- (B) F2
- (C) F3
- (D) P1

Q21. BIO

A test cross is made to check the genotype of a trait. Which of the following crosses is a test cross?

- (A) Unknown x At
- (B) Unknown x tt
- (C) Unknown x AB
- (D) Unknown x TT

Q22. BIO

During the sliding of actin filaments, ATP is used for?

- (A) Cross bridge formation
- (B) Cross bridge breaking
- (C) Dragging filaments
- (D) Shortening of filaments

Q23. BIO

The cell membrane of a muscle cell is:

- (A) Sarcoplasm
- (B) Sarcolemma
- (C) Sarcomere
- (D) Myofibrils

Q24. BIO

Irregular striation and involuntary control is related to:

- (A) Smooth muscle cells
- (B) Cardiac muscle cells
- (C) Skeletal muscle cells
- (D) Fibroelastic cartilage cells

Q25. BIO

Cartilage is a type of what tissue?

- (A) Connective tissues
- (B) Epithelial tissues
- (C) Muscular tissues
- (D) Nervous tissues

Q26. BIO

Production of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) from the pituitary gland of a female is controlled by:

- (A) Ovary
- (B) Uterus
- (C) Stimulated follicles
- (D) Hypothalamus

Q27. BIO

The term menopause means:

- (A) Start of menstruation
- (B) Start of ovulation
- (C) Stop of ova production
- (D) Degeneration of ovaries

Q28. BIO

To study sex linkages in *Drosophila*, Morgan mated white-eyed males with wild-type red-eyed females. What will be the phenotype of the offspring?

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

Q29. BIO

Enteron is the characteristic feature of:

- (A) Phylum Porifera
- (B) Phylum Cnidaria
- (C) Phylum Platyhelminthes
- (D) Phylum Echinodermata

Q30. BIO

The body of which is called metamerically segmented?

- (A) Cnidarians
- (B) Nematodes
- (C) Annelids
- (D) Sponges

Q31. BIO

Excretion in *Planaria* takes place by?

- (A) Malpighian tubules
- (B) Protonephridia
- (C) Metanephridia
- (D) Nephron

Q32. BIO

A four-chambered heart with a right systemic arch only is present in?

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

Q33. BIO

The movement of water to a lower solute concentration area through a semipermeable membrane is?

- (A) Osmotic potential
- (B) Pressure potential
- (C) Soil potential
- (D) Solute potential

Q34. BIO

The _____ describes how water and dissolved chemicals are carried through the cell wall and intercellular gaps of plants.

- (A) Apoplast Theory
- (B) Symplast Theory
- (C) Vacuolar Theory
- (D) Cytoplasmic Theory

Q35. BIO

Feeding by living in or on the other organism (host) belonging to different species is called?

- (A) Mineral nutrition
- (B) Parasitic nutrition
- (C) Saprophytic nutrition
- (D) Symbiotic nutrition

Q36. BIO

Which of the following viruses contains single-stranded DNA?

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

Q37. BIO

Which one of the following is an X-linked dominant disorder?

- (A) Haemophilia
- (B) Color blindness
- (C) Hypophosphatemic rickets
- (D) Becker muscular dystrophy

Q38. BIO

Only those genes can assort independently whose loci are on:

- (A) Same chromatids
- (B) Same chromosomes
- (C) Non-homologous chromosomes
- (D) Homologous chromosomes

Q39. BIO

Smooth muscles are found in all the mentioned below except:

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

Q40. BIO

The method of bringing oxygenated air into contact with a gas exchange surface is called:

- (A) Photorespiration
- (B) Ventilation
- (C) Gaseous transport
- (D) Respiration

Q41. BIO

The number of layers of the cell wall in Gram-positive bacteria is:

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

Q42. BIO

Helicobacter pylori is an example of:

- (A) Cocci
- (B) Bacilli
- (C) Pleomorphic
- (D) Spiral

Q43. BIO

Bacterial cells can maintain their shape through:

- (A) Cell wall
- (B) Capsule
- (C) Cell wall & slime
- (D) Slime

Q44. BIO

Which of the following is an example of spiral-shaped bacteria?

- (A) *Diplococcus pneumoniae*
- (B) *Hyphomicrobium*
- (C) *Escherichia coli*
- (D) *Pseudomonas*

Q45. BIO

All the following are disinfectants to control bacterial growth except:

- (A) Tincture of Iodine
- (B) Potassium Permanganate
- (C) Mercuric Chloride
- (D) Hydrogen Peroxide

Q46. BIO

The function of hyaluronidase enzyme is:

- (A) Penetration of the sperm into the Ovum
- (B) Entrance of the sperm into the vagina tube
- (C) Entrance of the sperm into the fallopian
- (D) Inactivation of sperms after their failure to fertilize ovum

Q47. BIO

In human females, what is the small, pear-shaped, muscular, distensible, sac-like organ where gestation takes place?

- (A) Uterus
- (B) Kidney
- (C) Fallopian tube
- (D) Stomach

Q48. BIO

The labour pains to expel fetus are due to action of oxytocin on:

- (A) Endometrium
- (B) Myometrium
- (C) Perimetrium
- (D) Ovaries

Q49. BIO

A virus is what type of agent?

- (A) Cellular agent
- (B) Infectious agent
- (C) Non-infectious agent
- (D) Non-protein agent

Q50. BIO

The molecules used to control viruses during infection of animal cells are:

- (A) Interferons
- (B) Histone
- (C) Antigen
- (D) Serum

Q51. BIO

The provirus of HIV is structurally and chemically made up of:

- (A) ssRNA
- (B) ssDNA
- (C) dsRNA
- (D) dsDNA

Q52. BIO

Which of the following is used in baking?

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

Q53. BIO

Which is the major event in the electron transport chain?

- (A) ATP synthesis
- (B) Substitution
- (C) Decarboxylation
- (D) Isomerization

Q54. BIO

Out of 36 ATPs, how many are produced in the electron transport chain?

- (A) 28
- (B) 30
- (C) 32
- (D) 34

Q55. BIO

The major enzyme involved in the transfer of the phosphate group from ATP to glucose is:

- (A) Isomerase
- (B) Dehydrogenase
- (C) Kinase
- (D) Decarboxylase

Q56. BIO

_____ forms almost three-fourth of the body by weight.

- (A) Water
- (B) Protein
- (C) Carbohydrates
- (D) Lipids

Q57. BIO

Energy is ----- by the breakdown of complex molecules into simpler ones; such reactions are called catabolic reactions:

- (A) Released
- (B) Consumed
- (C) Absorbed
- (D) Destroyed

Q58. BIO

Biologically, it plays key roles in maintaining the integrity of lipid bilayer membranes:

- (A) Hydrophilic exclusion
- (B) Hydrophobic interactions
- (C) Specific heat capacity
- (D) Heat of vaporization

Q59. BIO

The specific heat of vaporization of water plays an important role in the regulation of heat produced by:

- (A) Reduction
- (B) Oxidation
- (C) Redox
- (D) None of above

Q60. BIO

Which type of bond must be broken for water to vaporize?

- (A) Nonpolar covalent bonds
- (B) Polar covalent bonds
- (C) Hydrogen bonds
- (D) Ionic bonds

Q61. BIO

Which statement is true regarding both starch and cellulose?

- (A) They are both polymers of glucose
- (B) They are geometric isomers of each other
- (C) They can both be digested by humans
- (D) They are both used for energy storage in plants

Q62. BIO

Most of the monosaccharides form a ring structure when in solution. For example, ribose will create a five cornered ring known as:

- (A) Glucopyranose
- (B) Ribofuranose
- (C) Glyceraldehyde
- (D) Acetaldehyde

Q63. BIO

Cyclosis and amoeboid movements are due to:

- (A) Microtubule
- (B) Cilia
- (C) Microfilaments
- (D) Intermediate filaments

Q64. BIO

Proteins and lipids are modified into glycoproteins and glycolipids by which cell organelle?

- (A) Golgi complex
- (B) Rough Endoplasmic Reticulum
- (C) Smooth Endoplasmic Reticulum
- (D) Ribosomes

Q65. BIO

Which structure of the prokaryotic cell will play the role of the mitochondrion?

- (A) Spores
- (B) Cyst
- (C) Nucleoid
- (D) Mesosomes

Q66. BIO

The cell wall of a prokaryotic cell is composed of:

- (A) Carbohydrates
- (B) Carbohydrates and Proteins
- (C) Proteins
- (D) Proteins & Lipids

Q67. BIO

Competitive inhibitors stop an enzyme from working by:

- (A) Changing the shape of the enzyme
- (B) Merging with the substrate instead
- (C) Blocking the active site of the enzyme
- (D) Combining with the product of the reaction

Q68. BIO

After the digestion & before absorption, the product of the protein is:

- (A) Amino Acid and small polypeptide
- (B) Only Amino Acid
- (C) Only small polypeptide
- (D) Only ammonia

CHEM SECTION: CHEMISTRY

Questions 69 to 122 (54 MCQs)

Q69. CHEM

Which of the following transition metals show a 3d5 configuration in their +2 oxidation state?

- (A) Cu+2
- (B) Fe+2
- (C) Mn+2
- (D) Zn+2

Q70. CHEM

Which of the following reagents can be used to distinguish between 1-pentyne and 2-pentyne?

- (A) AgNO₃ + NH₄OH
- (B) 1% alkaline dilute KMnO₄
- (C) Br₂/CCl₄
- (D) K₂Cr₂O₇ + H₂SO₄

Q71. CHEM

In S_N1 reactions, the correct order of reactivity of alkyl halide is?

- (A) Primary > secondary > tertiary
- (B) Tertiary > secondary > primary
- (C) Secondary > primary > tertiary
- (D) Primary > tertiary > secondary

Q72. CHEM

What is the IUPAC name of diisopropyl ketone?

- (A) 1,3-Diisopropylpropan-2-one
- (B) 2,4-Dimethylpentan-3-one
- (C) 2,4-Dimethylpentan-2-one
- (D) 1,3-Dimethylpropan-2-one

Q73. CHEM

The appearance of a silver mirror in Tollen's test indicates the presence of which of the following?

- (A) ketone
- (B) An aldehyde
- (C) An acid
- (D) An alcohol

Q74. CHEM

If phenol is treated with 3 moles of conc. HNO₃ in the presence of H₂SO₄, what will be the product?

- (A) o-nitrophenol
- (B) p-nitrophenol
- (C) o-nitrophenol and p-nitrophenol
- (D) picric acid

Q75. CHEM

When the 6d orbital is filled, the entering electron goes into?

- (A) 7f
- (B) 7d
- (C) 7p
- (D) 7s

Q76. CHEM

Which element has the ground state electronic configuration of 1s², 2s², 2p⁶, 3s², 3p⁶?

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

Q77. CHEM

What is the proton (atomic number) of an element that has four unpaired electrons in its ground state?

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

Q78. CHEM

Which one of the following gases has the lowest density under room conditions?

- (A) Neon
- (B) Nitrogen
- (C) Oxygen
- (D) Fluorine

Q79. CHEM

The process of heat flow between hotter and colder gases remains continued until all the molecules have equal:

- (A) Average translational kinetic energy
- (B) Average rotational kinetic energy
- (C) Average translational potential energy
- (D) Average vibrational kinetic energy

Q80. CHEM

What is the ultimate fate of a reversible reaction?

- (A) Completion of the reaction
- (B) Complete consumption of reactants
- (C) Complete consumption of products
- (D) A state when there is no net concentration change

Q81. CHEM

In a reversible reaction, when a product is removed, the equilibrium shifts towards the:

- (A) Reactant side
- (B) Product side
- (C) Both sides, one by one
- (D) No effect

Q82. CHEM

The rate of reaction between two specific time intervals is called?

- (A) Instantaneous rate of reaction
- (B) Average rate of reaction
- (C) Rate of reaction
- (D) Minimum rate of reaction

Q83. CHEM

How will be the rate of reaction if the slope of the curve is greater near the start of the reaction?

- (A) Constant
- (B) Equilibrium
- (C) Greater
- (D) Lesser

Q84. CHEM

What is the reason for energy changes in chemical reactions?

- (A) Bond formation
- (B) Bond breakage
- (C) Bond formation and breakage
- (D) Ionic bonds

Q85. CHEM

What is the unit of heat capacity?

- (A) JK⁻¹
- (B) kJmol⁻¹
- (C) k/K
- (D) kJ.mol

Q86. CHEM

The addition reaction of 2-butene with HBr produces?

- (A) 1-bromobutane
- (B) 2-bromobutane
- (C) 2,3-dibromobutane
- (D) 1,3-dibromobutane

Q87. CHEM

Under suitable conditions alkanes cannot undergo _____ reactions?

- (A) Substitution
- (B) Combustion
- (C) Hydrogenation
- (D) Addition

Q88. CHEM

A compound of phosphorus oxide has 43.6% of oxygen. Its empirical formula is?

- (A) P₂O₅
- (B) P₂O₃
- (C) P₅O₂
- (D) PO₂

Q89. CHEM

Which element is used as a standard to determine the atomic mass of an element?

- (A) H
- (B) C
- (C) P
- (D) Cl

Q90. CHEM

The average weight of atoms of an element compared to the weight of one atom of _____ is called atomic weight.

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

Q91. CHEM

The same moles of H₂, N₂, and O₂ are present in 0.1 cc volume at STP. Which one has the greatest number of molecules:

- (A) N₂
- (B) H₂
- (C) O₂
- (D) Number of molecules are equal

Q92. CHEM

Which is not a property of liquid?

- (A) Osmotic pressure
- (B) Freezing point
- (C) Diffusion
- (D) Melting

Q93. CHEM

Which type of forces exist between iodine molecules?

- (A) Dipole-dipole forces
- (B) Dipole-induced dipole forces
- (C) Instantaneous dipole-induced dipole forces
- (D) Non-polar forces

Q94. CHEM

In anisotropic crystals, which property does not change with the change in direction of crystalline structure?

- (A) Electrical conductance
- (B) Thermal conductance
- (C) Molar mass
- (D) Refractive index

Q95. CHEM

In metals, why does electric conductivity decrease with the increase of temperature?

- (A) Because electron movement decrease with the increase of temperature
- (B) Because metal ions oscillations hinder electron movement
- (C) Because electron direction changes at high temperature
- (D) Because they pass heat current through collision of electrons

Q96. CHEM

Why does fluorine have less electron affinity as compared to bromine?

- (A) Electronegativity
- (B) Thick, small electronic cloud
- (C) Seven electrons in outermost shell
- (D) Higher ionization energy

Q97. CHEM

Which oxyacid of halogen is a strong oxidizing agent?

- (A) HClO₄
- (B) HClO₃
- (C) HClO
- (D) HClO₂

Q98. CHEM

Alkylbenzene is formed when benzene is treated with an alkyl halide in the presence of anhydrous aluminum chloride. Identify the type of reaction.

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

Q99. CHEM

The increasing stability order of the following compounds (1) CH₃CH₂CH₂+ (2) (CH₃)₃C+ (3) CH₃CH₂CH+ CH₃ are ?

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

Q100. CHEM

When 2-bromopropane reacts with sodium ethoxide, the major product is/are?

- (A) Propane
- (B) Propene
- (C) Ethyl isopropyl ether
- (D) All are formed

Q101. CHEM

Propanone can be prepared from propyne by:

- (A) Passing a mixture of propyne and steam over a catalyst, magnesium at 420°C
- (B) Passing a mixture of propyne and ethanol over a catalyst, zinc chromate
- (C) Boiling propyne with water in the presence of HgSO₄ and H₂SO₄
- (D) Treating propyne with iodine and NaOH

Q102. CHEM

If carboxylic acid and ketone groups C=O are present in a chain, then final name will be given as:

- (A) oxo, oic acid
- (B) one, oic acid
- (C) Both 1 and 2
- (D) None of these

Q103. CHEM

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

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

Q104. CHEM

Mr. Khan mixes acetic acid with thionyl chloride. Which product is obtained?

- (A) $\text{CH}_3\text{COCl} + \text{SO}_2 + \text{HCl}$
- (B) $\text{CH}_3\text{Cl} + \text{CH}_3\text{COCl}$
- (C) $\text{CH}_3\text{COOCH}_3 + \text{SO}_2$
- (D) $\text{CH}_3\text{Cl} + \text{SO}_2 + \text{HCl}$

Q105. CHEM

Dehydration of alcohol gives which of the following products in the presence of H_2SO_4 at 1400?

- (A) Acetaldehyde
- (B) Diethyl ether
- (C) Acetone
- (D) Ethyl chloride

Q106. CHEM

Complete oxidation of alcohol gives which of the following?

- (A) Aldehyde
- (B) Alkane
- (C) Carboxylic acid
- (D) Ketone

Q107. CHEM

One can estimate the direction in which the equilibrium will shift with the help of:

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

Q108. CHEM

The bond energy of hydrogen in the H_2 molecule is:

- (A) 242 KJ/mol
- (B) 431 KJ/mol
- (C) 436 KJ/mol
- (D) 346 KJ/mol

Q109. CHEM

What are vinyl alcohol and acetaldehyde?

- (A) Position isomers
- (B) Functional group isomers
- (C) Metameres
- (D) Tautomers

Q110. CHEM

What is the oxidation number of free magnesium?

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

Q111. CHEM

Select the metal that is extracted from bauxite.

- (A) Al
- (B) Ca
- (C) Mg
- (D) Cu

Q112. CHEM

Which of the following has the highest atomic radius in its period?

- (A) Alkaline earth metals
- (B) Alkali metals
- (C) Chalcogens
- (D) Halogens

Q113. CHEM

The electronic configurations of some elements are given below. Recognize the element that belongs to group IIIA

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

Q114. CHEM

All alkali metals react with chlorine gas to form white metal chloride salt. The metal chloride salt formed is:

- (A) Insoluble
- (B) Soluble in water to give neutral solution of pH 7
- (C) Soluble in water to give acidic solution of pH 1
- (D) Soluble in water to give alkaline solution of pH 14

Q115. CHEM

Which one of them is amphoteric in nature?

- (A) Lithium oxide
- (B) Beryllium oxide
- (C) Calcium oxide
- (D) Potassium oxide

Q116. CHEM

Which of the following is correct electronic configuration of iron (II) ion (atomic no. of Fe is =26)?

- (A) $[\text{Ar}] 4s^0, 3d^6$
- (B) $[\text{Ar}] 4s^2, 3d^6$
- (C) $[\text{Ar}] 4s^2, 3d^4$
- (D) $[\text{Ar}] 4s^2, 3d^5$

Q117. CHEM

Which of the functional groups are present in ethyl acetate?

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

Q118. CHEM

What is the molecular formula of the pyridine molecule?

- (A) $\text{C}_6\text{H}_5\text{N}$
- (B) $\text{C}_5\text{H}_5\text{N}$
- (C) $\text{C}_5\text{H}_5\text{NH}$
- (D) $\text{C}_6\text{H}_6\text{N}$

Q119. CHEM

Identify which method is used to prepare alkynes?

- (A) Dehalogenation of Vicinal Dihalides in the Presence of Methanol.
- (B) Dehydration of alcohols in the presence of Al_2O_3 at 340–450 degrees centigrade.
- (C) Dehalogenation of Vicinal Dihalides in the Presence of Strong Base.
- (D) Electrolysis of unsaturated dicarboxylic acid salts.

Q120. CHEM

Which of the following electronic configurations is correct for 24Cr?

- (A) $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$
- (B) $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4s^1, 3d^4$
- (C) $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 3d^6$
- (D) $1s^2, 2s^2, 2p^6, 3s^2, 3p^6, 4f^6$

Q121. CHEM

The following formula can be used to determine the resistance of a length of conductor: $R = \frac{\rho l}{A}$. In the formula, the symbol ρ stands for the:

- (A) Cross-sectional area of the conductor in m^2
- (B) Product of the length of the conductor in meters
- (C) Resistivity of the material in units of ohm-meters ($\Omega \cdot \text{m}$)
- (D) Resistance of the conductor in units of ohms per meter

Q122. CHEM

The resistance of the wire varies inversely as:

- (A) Area of cross-section
- (B) Length
- (C) Resistivity
- (D) Temperature

PHY SECTION: PHYSICS

Questions 123 to 176 (54 MCQs)

Q123. PHY

A capacitor of capacitance C has charge Q and stored energy is W . If the charge is increase to $2Q$. The stored energy will be:

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

Q124. PHY

To store the electric charge the ultra-capacitors use _____ effect.

- (A) Single layer
- (B) Double layer
- (C) Triple layer
- (D) Quadruple layer

Q125. PHY

What is the potential difference between two points in an electric field if it takes 600 J of energy to move a charge of 2 C between these two points?

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

Q126. PHY

A charged particle moves in a uniform electric field between two oppositely charged parallel metal plates to calculate the force acting on the particle due to the electric field, which quantity is not required?

- (A) Particle charge
- (B) Particle speed
- (C) Plate separation
- (D) Potential difference between the plates

Q127. PHY

Gauss law cannot be used to find which of the following quantity?

- (A) Electric field intensity
- (B) Electric flux density
- (C) Charge
- (D) permittivity

Q128. PHY

Electric field intensity inside a hollow charged sphere is:

- (A) Maximum
- (B) Zero
- (C) Negative
- (D) Positive

Q129. PHY

As per Coulomb's law, the force of attraction or repulsion between two-point charges is directly proportional to the:

- (A) Sum of the magnitude of charges
- (B) Square of the distance between them
- (C) Product of the magnitude of charges
- (D) Cube of the distance

Q130. PHY

For an ideal gas equation $PV = nRT$, the dimensions of Real Gas Constant R are:

- (A) $[M^1 L^2 T^{-2} K^{-1}]$
- (B) $[M^1 L^{-3} T^{-1} K^{-1}]$
- (C) $[M^1 L^{-2} T^{-1} K^{-1}]$
- (D) $[M^1 L^{-3} T^{-2} K^{-1}]$

Q131. PHY

A distant star is receding from the Earth with a speed of $1.40 \times 10^7\text{ m/s}$. It emits light of frequency $4.57 \times 10^{14}\text{ Hz}$. The speed of light is $3.0 \times 10^8\text{ m/s}$. The Doppler effect formula can be used with light waves. What will be the frequency of this light when detected on Earth?

- (A) $2.04 \times 10^{13}\text{ Hz}$
- (B) $4.36 \times 10^{14}\text{ Hz}$
- (C) $4.57 \times 10^{14}\text{ Hz}$
- (D) $4.79 \times 10^{14}\text{ Hz}$

Q132. PHY

The speed of sound in an ideal gas depends upon:

- (A) Ice
- (B) Frequency and fog
- (C) Temperature and density
- (D) Density and amplitude

Q133. PHY

If transverse waves are passing through a medium, then particles of the medium:

- (A) Remain stationary
- (B) Move away
- (C) Move toward
- (D) Move in Simple Harmonic Motion

Q134. PHY

When a wave goes from one medium to another, there is a no change in the:

- (A) Frequency
- (B) Amplitude
- (C) Wavelength
- (D) Velocity

Q135. PHY

Wave trough refers to the:

- (A) Wave length
- (B) Wave speed
- (C) Highest point of the wave
- (D) Lowest point of the wave

Q136. PHY

First law of thermodynamics concerns with the conservation of:

- (A) Heat
- (B) Work
- (C) Momentum
- (D) Energy

Q137. PHY

An ideal gas has molar specific heat C_p at constant pressure. When the temperature of n moles is increased by ΔT the increase in the internal energy is:

- (A) $nC_p \Delta T$
- (B) $n(C_p + R) \Delta T$
- (C) $n(C_p - R) \Delta T$
- (D) $n(2C_p + R) \Delta T$

Q138. PHY

The ohmmeter of a portable digital multi meter need:

- (A) Internal battery
- (B) Wet cell
- (C) Voltmeter
- (D) Ammeter

Q139. PHY

A wire of uniform area of cross-section 'A', length 'L', and resistance R is cut into two equal parts. What will happen to the resistivity of each part?

- (A) It will be doubled
- (B) It will be one fourth
- (C) It will be halved
- (D) It will remain the same

Q140. PHY

If 0.5 T field is applied over an area of 2-meter square which lies at an angle of 60 degree with the field, then the resulting flux will be:

- (A) 0.5 T
- (B) 0.5 Wb
- (C) 0.25 Wb
- (D) 0.25 T

Q141. PHY

The magnitude of magnetic force will be maximum on current carrying conductor in uniform magnetic field if conductor is placed?

- (A) Parallel to magnetic field
- (B) At 45 degree in magnetic field
- (C) Perpendicular to magnetic field
- (D) Antiparallel in magnetic field

Q142. PHY

In principle, the transformer consists of two coils of copper, electrically insulated from each other, wound on the same?

- (A) Iron core
- (B) Copper core
- (C) Gold core
- (D) Steel core

Q143. PHY

In Compton effect, the incident photon when compared to the scattered photon is of:

- (A) Greater energy
- (B) Greater frequency
- (C) Greater energy and momentum
- (D) Equal energy

Q144. PHY

Which of the following is the longest wavelength of radiation for the Paschen series?

- (A) 187000000 m
- (B) 187000000 / m
- (C) 0.00000187 m
- (D) 0.00000187 / m

Q145. PHY

Which of the following is the correct definition of variable velocity?

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

Q146. PHY

Which of the following is the fractional change in resistance per kelvin?

- (A) Conductivity
- (B) Resistivity
- (C) Temperature coefficient of resistivity
- (D) Temperature coefficient of resistance

Q147. PHY

According to maximum power transfer theorem, which of the following is the max power delivered by the battery to the output?

- (A) $E^2/4r$
- (B) $E^2/2r$
- (C) $E^2/5r$
- (D) $E^2/3r$

Q148. PHY

Velocity selector will select only those charge particles whose velocity is given by:

- (A) $V = E/B$
- (B) $V = B/E$
- (C) $V = ExB$
- (D) $V = 0$

Q149. PHY

The induced emf produced in the coil is sometimes called as?

- (A) Self-inductance
- (B) Back emf
- (C) Motional emf
- (D) Mutual inductance

Q150. PHY

The quantity $\Delta\phi/\Delta t$ has the same units as that of?

- (A) Current
- (B) Magnetic Induction
- (C) Charge
- (D) Emf

Q151. PHY

Voltage has the same units as that of?

- (A) Current
- (B) Magnetic induction
- (C) Emf
- (D) Mutual inductance

Q152. PHY

Working principal of magnetic levitation train is according to?

- (A) Faraday law
- (B) Max planks law
- (C) Ohm law
- (D) Lenz law

Q153. PHY

The expression for the emf produced by A. C. generator is?

- (A) $N\omega AB \sin\theta$
- (B) $N\omega AB \cos\theta$
- (C) $N\omega AB$
- (D) $ILB \cos\theta$

Q154. PHY

For the positive half cycle i.e., $0 \rightarrow T/2$, the diode D:

- (A) Is reverse biased
- (B) Is forward biased
- (C) Behaves as open
- (D) Shows maximum resistance

Q155. PHY

The process of ejection of loosely bound electrons from a certain photo sensitive surface by absorption of photon is called:

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

Q156. PHY

In Compton effect, a photon of a certain wavelength collides with a stationary electron. The wavelength of the emitted photon is:

- (A) Longer
- (B) Shorter
- (C) Same
- (D) Infinite

Q157. PHY

The Balmer series of hydrogen is important because it:

- (A) Is the only one for which the quantum theory be used
- (B) Is the only series that occurs for hydrogen
- (C) Is in the visible region
- (D) Involves the lowest possible quantum number "n"

Q158. PHY

The SI unit of equivalent dose is:

- (A) Gray
- (B) Mass
- (C) Rad
- (D) Sievert

Q159. PHY

The decay rate of radioactive substance is:

- (A) Constant with time
- (B) Varies inversely with time
- (C) Decreases exponentially with time
- (D) Decreases linearly with time

Q160. PHY

The relation between gray and rad is given as: 1 Gy = _____ rad

- (A) 0.01
- (B) 0.001
- (C) 10
- (D) 100

Q161. PHY

The velocity–time plot for a moving particle shows a straight line. This means:

- (A) The particle has a constant acceleration
- (B) The particle has never turned around
- (C) The particle has zero displacement
- (D) The data is insufficient

Q162. PHY

A man is in a car that is moving with the velocity of 36km/hr. His speed with respect to the car:

- (A) 10m/s
- (B) 36m/s
- (C) Zero
- (D) Infinite

Q163. PHY

On which car there is resultant force?

- (A) Car moving on a straight horizontal road
- (B) Car moving at constant speed around a bend
- (C) Car moving uphill at a constant velocity
- (D) Car that is stationary

Q164. PHY

If two equal masses are in motion with same individual speeds, we can conclude that:

- (A) Their momentums are same
- (B) Their momentums can be different from each other
- (C) Their kinetic energies are different from each other
- (D) Their total energies are same

Q165. PHY

The work done by a variable force can be found by dividing the:

- (A) Force into small intervals
- (B) The displacement into small intervals
- (C) Both force and displacement into small intervals
- (D) By taking displacements at different angles

Q166. PHY

Two bodies with kinetic energies having a ratio of 4:1, are moving with equal linear momentum. The ratio of their masses is:

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

Q167. PHY

A fisherman lifts a fish of mass 250 g from rest through a vertical height of 1.8 m. The fish gains a speed of 1.1 m/s. What is the energy gained by the fish?

- (A) 0.15 J
- (B) 4.3 J
- (C) 4.4 J
- (D) 4.6 J

Q168. PHY

One radian is analogous to:

- (A) 57°3'
- (B) 57°3"
- (C) 57°18'
- (D) 57°18"

Q169. PHY

In the displacement–time graph, if the slope is constant then the velocity is

- (A) Variable
- (B) Constant
- (C) May be variable or constant
- (D) Infinite

Q170. PHY

An 8.0–kg box slides along a horizontal frictionless floor at 3 m/s and collides with a relatively massless spring that compresses 12 cm before the box comes to a rest. Calculate the retarding force of the spring.

- (A) 3N
- (B) 30N
- (C) 300N
- (D) 3000N

Q171. PHY

The circular line has a fix distance from _____?

- (A) Any point
- (B) A fix point
- (C) A point on a circle
- (D) A point from outside

Q172. PHY

If a particle is moving with uniform circular motion, then:

- (A) Velocity and acceleration are antiparallel
- (B) Velocity and acceleration are parallel
- (C) Velocity and acceleration are perpendiculars
- (D) Zero acceleration

Q173. PHY

One degree is equal to:

- (A) $n/90$ radians.
- (B) $n/180$ radians.
- (C) $n/270$ radians.
- (D) $n/360$ radians.

Q174. PHY

An observer standing near the sea shore observes 54 waves per minute. If the wavelength of the water wave is 10m then the velocity of water wave is:

- ☐ A 540 m/s
- ☐ B 9 m/s
- ☐ C 5.4 m/s
- ☐ D None

Q175. PHY

If the length of second pendulum becomes four times, then its time period will become:

- ☐ A Four times
- ☐ B Two times
- ☐ C Half
- ☐ D one fourth

Q176. PHY

Choose the sentence that is grammatically correct:

- ☐ A He weighed himself two pounds.
- ☐ B He weighed two pounds.
- ☐ C He weighed themselves two pounds.
- ☐ D He weighed itself two pounds.

ENG SECTION: ENGLISH

Questions 177 to 194 (18 MCQs)

Q177. ENG

Choose the sentence that is grammatically correct:

- (A) He weighed himself maunds.
- (B) He weighed two maunds.
- (C) He weighed themselves two.
- (D) He weighed itself two maunds.

Q178. ENG

Choose the correct option.

We felt as if the ground was _____ beneath our feet.

- (A) Digging
- (B) Sinking
- (C) Slipping
- (D) Bursting

Q179. ENG

A few years ago, it _____ that human beings do not belong to this earth.

- (A) Found
- (B) Was found
- (C) Were found
- (D) Had found

Q180. ENG

A shoal of fish _____ killed by the fishermen.

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

Q181. ENG

At last the fly was _____. The most appropriate word to be filled in is:

- (A) Trapped by the spider
- (B) Entertained by the spider
- (C) Invited by the spider
- (D) Spared by the spider.

Q182. ENG

Choose the correct meaning of the underlined word:

Provisionally, his mind was not injured.

- (A) Slowly
- (B) Suddenly
- (C) Luckily
- (D) Unfortunately

Q183. ENG

A carpenter carves _____ on cab doors. Choose the right word to fill in the blank.

- (A) Arabesque
- (B) Ornate
- (C) Decked
- (D) Floral

Q184. ENG

Choose the correct option.

_____ methods don't work.

- (A) This
- (B) These
- (C) The
- (D) That

Q185. ENG

We just _____ a game of tennis.

- (A) Has
- (B) Had
- (C) Have
- (D) Have had

Q186. ENG

The pen is expensive; still, I _____ it.

- (A) Bought
- (B) Will buy
- (C) Have bought
- (D) Buyed

Q187. ENG

Punctuate the given sentence correctly.

My father is Chairman of the Committee on Internal Relations he also heads the Discipline Committee.

- (A) My father is Chairman of the Committee on Internal Relations. He also heads the Discipline Committee.
- (B) My father is Chairman of the Committee on Internal Relations - he also heads the Discipline Committee.
- (C) My father is Chairman of the Committee on Internal Relations: he also heads the Discipline Committee.
- (D) My father is Chairman of the Committee on Internal Relations, but he also heads the Discipline Committee.

Q188. ENG

Which of the following sentences is correct?

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

Q189. ENG

Read the following passage to answer the given question:

Right after the Civil War, many distraught soldiers made their way West to find fame and fortune. Some could not go home because there were no homes to go to. The war had devastated them. One young man, Will Goodlad, made his fortune in the hills of Colorado. He found gold in a little river near Grand Junction. His fortune was short lived, however. In 1875, he declared bankruptcy and returned to the land of his birth- the Piedmont of South Carolina.

For which side did Will fight during the War?

- (A) East
- (B) West
- (C) North
- (D) South

Q190. ENG

Which part is the most appropriate to be filled in the blank?

_____ so many people been out of work as today.

- (A) More than ever before
- (B) Never before have
- (C) In the past, there never have
- (D) Formerly, there never were

Q191. ENG

Spot the error in the given sentence:

We try to speak with (A) one another (B) but (D) convey (C) nothing.

- (A) With
- (B) One another
- (C) Convey
- (D) But

Q192. ENG

Choose the part of the sentence that carries error:

In winter (A), the days (B) and nights (C) is cold (D).

- (A) In winter
 - (B) The days
 - (C) And nights
 - (D) Is cold
-

Q193. ENG

Choose the correct option.

We felt as if the ground was _____ beneath our feet.

- (A) Digging
 - (B) Sinking
 - (C) Slipping
 - (D) Bursting
-

Q194. ENG

Choose the sentence that carries an error regarding pronoun usage:

- (A) He weighed himself two maunds.
 - (B) He weighed two maunds.
 - (C) They weighed two maunds.
 - (D) She weighed two maunds.
-

LOGIC SECTION: LOGICAL REASONING

Questions 195 to 200 (6 MCQs)

Q195. 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

Q196. LOGIC

Read the following and choose the correct answer

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 35. 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

Q197. LOGIC

Observe the pattern and select the next term in the sequence: SSSSS, SSRSS, SRQRS, RQPQR

- (A) RQDQR
- (B) QRORQ
- (C) RQPOPQR
- (D) QPOPQ

Q198. LOGIC

Read the following statement, assuming everything in it to be true. Then decide which of the given suggested courses of action logically follow and are worth pursuing.

Statement: Your toddler drops and breaks a glass by genuine accident.

Courses of Action:

- I. yell at them to be more careful with things made out of glass.
- II. Punish them to make sure they remember to be extra careful next time.

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

Q199. LOGIC

Read the following statements and identify the best cause and effect relation.

- I. State P started providing multiple rehabilitation schemes, like free education, job search help and help groups for addicts, etc. over the past year.
- II. Crimes rates for state P have steadily decreased over the past year.

- (A) II is the cause and I is its effect
- (B) I is the cause and II is its effect
- (C) I and II are effects of some common cause
- (D) I and II are both effects of independent causes

Q200. LOGIC

Read the passage and the following statements below. Then choose the correct option, basing your answer only on the information provided.

Pakistan is rich in wildlife and culture. It is home to many sorts of wildlife, from the Ibex to the Indus River Dolphin ; and people from most countries in the world have made their home here. Statements :

- i. Pakistan is rich country
- ii. People from all nationalities of the world live in Pakistan.
- iii. Pakistan is home to at least one dolphin species.

- (A) Only iii statement is correct
- (B) Only i and ii are correct
- (C) Only i and iii are correct
- (D) Only ii and iii are correct

OFFICIAL VERIFIED ANSWER KEY

UHS Lahore MDCAT 2023 Official Paper - Rapid Self-Grading Grid

[Online Portal >](#)

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

Which of the following is the main point of Darwinism?

CORE CONCEPT & DERIVATION

Darwinism centers on descent with modification driven primarily by differential reproductive success operating on heritable variations.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Charles Darwin proposed that natural selection is the principal mechanism of evolution, wherein organisms with advantageous variations survive, reproduce, and pass those traits to offspring.
- In contrast, the use and disuse of parts, such as the loss of snake legs or muscle atrophy, are tenets of Lamarckism.

Why other options are incorrect:

- Option A:** The loss of snake legs through disuse is a classic example used in Lamarck's theory of inheritance of acquired characteristics.
- Option C:** Muscle atrophy from lack of exercise represents phenotypic plasticity or disuse, not Darwinian natural selection.
- Option D:** Ear muscle movement refers to vestigial muscular apparatus described under comparative anatomy, not the central driving mechanism of Darwinism.

Question #2 Key: (B)

BIOLOGY
16. Evolution

According to evolutionary studies, prokaryotes may have arisen around:

CORE CONCEPT & DERIVATION

Microfossil evidence and stromatolite records indicate that primitive cellular life originated during the Archean Eon.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Geological and fossil records establish that the earliest single-celled prokaryotic organisms arose approximately 3.5 to 3.8 billion years ago.
- The Earth itself formed approximately 4.5 to 4.6 billion years ago, meaning life appeared roughly one billion years after planetary accretion.

Why other options are incorrect:

- Option A:** 2.5 billion years ago corresponds to the Great Oxidation Event and the emergence of early eukaryotic cells, not the first prokaryotes.
- Option C:** 4.5 billion years ago marks the approximate formation of Earth, during which surface temperatures were incompatible with cellular integrity.
- Option D:** 5.5 billion years ago predates the accretion of the Earth and the solar system.

Question #3 Key: (D)

BIOLOGY
06. Digestion/Nutrition

The enzyme which can work on pH 7 of the medium is:

CORE CONCEPT & DERIVATION

Every enzyme operates within a characteristic optimum pH range determined by the ionization state of the catalytic amino acid residues at its active site.

Formula / Rule / Reaction:

Optimum pH range for chymotrypsin $\approx 7.0 - 8.0$

Solution:

- Chymotrypsin is a serine protease secreted as chymotrypsinogen by the pancreas and functions in the duodenum at a neutral to slightly alkaline pH of 7.0 to 8.0.
- At pH 7.0, its catalytic triad (Ser-195, His-57, Asp-102) remains properly protonated and ionized for peptide bond cleavage.

Why other options are incorrect:

- Option A:** Pepsin operates in the highly acidic gastric juice with an optimum pH of 1.5 to 2.0; it is denatured at pH 7.0.
- Option B:** Sucrase functions optimally in moderately acidic conditions around pH 4.5 to 6.0.
- Option C:** Pancreatic lipase requires an alkaline medium with an optimum pH between 8.0 and 9.0 along with bile salts.

Question #4 Key: (D)

BIOLOGY
06. Digestion/Nutrition

Which enzyme is different from others?

CORE CONCEPT & DERIVATION

Enzymes are systematically categorized based on the specific substrate bonds they hydrolyze.

Formula / Rule / Reaction:

Lactase + Lactose $\rightarrow$ Glucose + Galactose (Glycosidic cleavage)

Solution:

- Pepsin, trypsin, and chymotrypsin are all proteases (peptidases) that cleave peptide bonds in polypeptides.
- Lactase is a disaccharidase (carbohydrase) that hydrolyzes the β -1,4-glycosidic bond in lactose to produce glucose and galactose.

Why other options are incorrect:

- Option A:** Pepsin is a protein-cleaving endopeptidase.
- Option B:** Trypsin is an alkaline protein-cleaving endopeptidase.
- Option C:** Chymotrypsin is also a protein-cleaving endopeptidase.

Question #5 Key: (A)BIOLOGY
03. Enzymes

Competitive inhibitors are:

CORE CONCEPT & DERIVATION

Competitive inhibition occurs when a molecule possesses structural homology or similarity to the natural substrate, allowing it to occupy the active site.

Formula / Rule / Reaction:



Solution:

- According to the Punjab Textbook of Biology, competitive inhibitors exhibit structural homology to the substrate and directly compete for binding at the catalytic active site.
- Because of this structural resemblance, the inhibitor reversibly binds the free enzyme to form an inactive enzyme-inhibitor (EI) complex. Note: While modern biochemistry often describes them as structural analogs, the official provincial textbook and key explicitly designate them as homologous to the substrate.

Why other options are incorrect:

- Option B:** Although analogous denotes functional similarity, the provincial curriculum text specifically uses the terminology of structural homology.
- Option C:** Molecular size alone does not dictate competitive inhibition; exact steric fit to the active site residues is required.
- Option D:** An inhibitor that is significantly larger than the substrate would generally cause steric clash and fail to fit inside the active site cleft.

Question #6 Key: (D)BIOLOGY
03. Enzymes

The active sites of enzymes are composed of:

CORE CONCEPT & DERIVATION

The active site of a globular enzyme is a specialized three-dimensional crevice formed by a small number of specific amino acid residues.

Formula / Rule / Reaction:

Active site = Binding site + Catalytic site (composed of specific amino acid R-groups)

Solution:

- Enzymes are globular proteins composed of folded polypeptide chains.
- Only a few amino acids (typically 3 to 12) directly participate in binding the substrate and catalyzing the transformation; the rest of the protein maintains the requisite three-dimensional tertiary conformation.

Why other options are incorrect:

- Option A:** Nucleotides constitute nucleic acids (RNA/DNA), not the active sites of standard proteinaceous enzymes.
- Option B:** Nucleosides consist of a nitrogenous base and a pentose sugar without phosphate groups, playing no structural role in protein catalytic sites.
- Option C:** Saccharides are carbohydrates; though present in glycoproteins, they do not constitute the catalytic machinery of enzyme active sites.

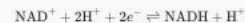
Question #7 Key: (B)BIOLOGY
03. Enzymes

NAD is an important:

CORE CONCEPT & DERIVATION

Coenzymes are non-protein organic cofactors that loosely associate with apoenzymes to facilitate catalytic transfers of electrons or functional groups.

Formula / Rule / Reaction:



Solution:

- Nicotinamide adenine dinucleotide (NAD) is a dinucleotide coenzyme derived from vitamin B3 (niacin).
- It functions as a universal electron carrier in metabolic redox reactions, cycling between its oxidized (NAD^+) and reduced (NADH) states during glycolysis, the link reaction, and the Krebs cycle.

Why other options are incorrect:

- Option A:** NAD is not an enzyme because it lacks catalytic polypeptide structure and acts as a substrate-like cofactor.
- Option C:** Hormones are intercellular chemical messengers secreted by endocrine glands, unlike intracellular metabolic coenzymes.
- Option D:** Although synthesized from niacin (a vitamin), NAD itself is a complex dinucleotide coenzyme.

Question #8 Key: (D)BIOLOGY
13. Chemical Coordination

What is true about oxytocin?

CORE CONCEPT & DERIVATION

Oxytocin is a nonapeptide neurohormone synthesized in the paraventricular nuclei of the hypothalamus and released by the posterior pituitary to stimulate smooth muscle contraction.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Oxytocin stimulates the contraction of myoepithelial cells surrounding the alveoli of the mammary glands.
- This contraction forces milk into the lactiferous sinuses and dilates the milk ducts, promoting milk ejection (milk letdown reflex).
- It also stimulates rhythmic contractions of the uterine myometrium during parturition.

Why other options are incorrect:

- Option A:** Antidiuretic hormone (ADH / vasopressin), not oxytocin, acts on the collecting ducts and distal tubules of the kidney.
- Option B:** Gonadotropin-releasing hormone (GnRH) stimulates ICSH (LH) secretion from the anterior pituitary.
- Option C:** Performing general cellular functions is a non-specific phrase that does not describe the hormonal mechanism of oxytocin.

Question #9 Key: (A)BIOLOGY
12. Nervous Coordination

In a typical nerve, the action potential duration is:

CORE CONCEPT & DERIVATION

An action potential in a non-myelinated axon is an all-or-none electrophysiological event lasting approximately one millisecond.

Formula / Rule / Reaction:

$$\Delta t_{\text{action potential}} \approx 1 \text{ ms} = 10^{-3} \text{ s}$$

Solution:

- Depolarization caused by rapid Na^+ influx occurs within approximately 0.5 ms.
- Repolarization via voltage-gated K^+ efflux takes another 0.5 ms, bringing the total duration of the nerve impulse spike to approximately 1 millisecond.

Why other options are incorrect:

- **Option B:** One microsecond (10^{-6} s) is far too rapid for the physical opening and closing kinetics of voltage-gated ion channels.
- **Option C:** One second is characteristic of slow biological cycles, not individual neuronal impulses which fire at rates up to several hundred per second.
- **Option D:** One minute is an enormous timescale in neurophysiology; nerves would be unable to transmit continuous rapid stimuli.

Question #10 Key: (A)BIOLOGY
12. Nervous Coordination

During resting membrane potential condition:

CORE CONCEPT & DERIVATION

The resting membrane potential represents an electrical polarization across the neuronal membrane maintained primarily by the sodium-potassium pump and potassium leak channels.

Formula / Rule / Reaction:

$$V_m = -70 \text{ mV (relative to the extracellular fluid)}$$

Solution:

- In an unexcited resting neuron, the Na^+/K^+ ATPase pumps 3 Na^+ ions outward for every 2 K^+ ions inward.
- Additionally, non-diffusible intracellular organic anions (proteins, organic phosphates) remain trapped in the axoplasm, while K^+ continuously leaks out, resulting in a net excess of positive charges on the outer surface relative to the inside.

Why other options are incorrect:

- **Option B:** The inner surface is negatively charged relative to the outer surface at rest.
- **Option C:** If both surfaces were equally positive, the potential difference (V_m) would be zero millivolts.
- **Option D:** An equal negative charge on both sides would eliminate the voltage gradient required for impulse conduction.

Question #11 Key: (C)BIOLOGY
12. Nervous Coordination

The value of the active membrane potential of the neuron is:

CORE CONCEPT & DERIVATION

Depolarization during an action potential causes the interior of the neuron to become positively charged, peaking at approximately +50 mV.

Formula / Rule / Reaction:

$$V_{\text{active}} = +50 \text{ mV} = +0.050 \text{ V}$$

Solution:

- At the crest of the action potential, voltage-gated sodium channels allow rapid influx of Na^+ until the membrane reverses polarity from -70 mV to $+50 \text{ mV}$.
- Converting millivolts to volts gives:

$$50 \text{ mV} = \frac{50}{1000} \text{ V} = 0.05 \text{ volts}$$

Why other options are incorrect:

- **Option A:** 0.01 volts corresponds to 10 mV, which is below the depolarization peak.
- **Option B:** 0.02 volts corresponds to 20 mV, which is roughly the threshold level relative to resting potential.
- **Option D:** 0.07 volts corresponds to 70 mV, which represents the magnitude of the resting potential (-70 mV), not the active potential.

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

The chemical messengers that transmit action potential across the synapse in the form of chemi...

CORE CONCEPT & DERIVATION

Chemical transmission at synapses involves the exocytosis of specific chemical messengers across the synaptic cleft.

Formula / Rule / Reaction:

$$\text{Action potential} \rightarrow \text{Ca}^{2+} \text{ influx} \rightarrow \text{Exocytosis of neurotransmitter} \rightarrow \text{Postsynaptic receptor binding}$$

Solution:

- Neurotransmitters (such as acetylcholine, dopamine, and norepinephrine) are packaged in synaptic vesicles within the presynaptic terminal.
- When an action potential arrives, calcium influx triggers vesicle fusion, releasing neurotransmitters into the synaptic cleft to bind postsynaptic receptors and initiate an electrical change.

Why other options are incorrect:

- **Option A:** The synaptic knob is the swollen terminal bulb of the axon, which is an anatomical structure rather than a chemical messenger.
- **Option B:** Reflex action is an involuntary, rapid motor response pathway, not a chemical substance.
- **Option D:** Acetylcholinesterase is an enzyme that degrades acetylcholine in the synaptic cleft, rather than a transmitter molecule.

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

The pressure receptors that receive deep pressure stimulus in the human body are called:

CORE CONCEPT & DERIVATION

Mechanoreceptors in the skin and connective tissues are structurally adapted to detect distinct mechanical modalities such as light touch, vibration, and deep pressure.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Pacinian corpuscles (lamellar corpuscles) consist of a central unmyelinated nerve ending surrounded by concentric connective tissue lamellae.
- They reside deep in the dermis, subcutaneous tissue, and joint capsules, functioning as rapidly adapting mechanoreceptors specialized for detecting deep pressure and high-frequency vibration.

Why other options are incorrect:

- **Option A:** Meissner corpuscles reside in dermal papillae and detect light touch and low-frequency flutter.
- **Option C:** Red blood corpuscles (erythrocytes) are circulatory cells that transport oxygen, not sensory receptors.
- **Option D:** Cholesterol is a structural steroid lipid found in plasma membranes.

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

Cells of different types can be distinguished on the basis of surface:

CORE CONCEPT & DERIVATION

The glycocalyx consists of carbohydrate moieties attached to membrane lipids and proteins, acting as specific molecular signatures for cell-cell recognition.

Formula / Rule / Reaction:

Cell identity marker = Oligosaccharide chains conjugated to proteins (glycoproteins) or lipids (glycolipids)

Solution:

- Glycoproteins and glycolipids extend outward from the external leaflet of the plasma membrane.
- Their branched oligosaccharide configurations vary among cell types and individuals, functioning as immunological markers (such as ABO blood group antigens) and tissue-specific recognition labels.

Why other options are incorrect:

- **Option A:** Phospholipids form the universal structural matrix of the lipid bilayer and are fundamentally identical across human cell types.
- **Option B:** Globular proteins function generally as transporters, channels, or enzymes, but generic globular structure does not serve as the cellular fingerprint.
- **Option D:** Cholesterol intercalates between phospholipids to buffer membrane fluidity and is not a cell-identifying surface marker.

Question #15 Key: (D)BIOLOGY
01. Cell

Mitosis, a type of cell division, is observed in:

CORE CONCEPT & DERIVATION

Mitosis is a eukaryotic process requiring a nuclear envelope, spindle apparatus, and linear chromosomes packaged with histones.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Prokaryotes lack a nucleus, histones, and a microtubular spindle apparatus.
- *Escherichia coli* is a bacterium, while *Nostoc* and all other Cyanobacteria (blue-green algae) are prokaryotes; they reproduce asexually by binary fission, not mitosis.
- Therefore, mitosis is not observed in any of the listed organisms.

Why other options are incorrect:

- **Option A:** *E. coli* is a prokaryotic bacterium dividing exclusively via binary fission.
- **Option B:** *Nostoc* is a filamentous cyanobacterium that undergoes binary fission and fragmentation.
- **Option C:** Cyanobacteria are prokaryotes that do not possess mitotic machinery.

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

Which of the following types of organs are supposed to be functional in ancestral species rather than in present-day species?

CORE CONCEPT & DERIVATION

Evolutionary reduction leads to anatomical remnants that were functional in ancestors but have lost their primary utility in modern descendants.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Vestigial organs are rudiments of structures that performed significant functions in ancestral species.
- Examples in humans include the vermiform appendix, coccyx, wisdom teeth, and auricular muscles, providing strong anatomical evidence for common descent.

Why other options are incorrect:

- **Option B:** Homologous organs share a common anatomical ancestry and developmental origin, and remain fully functional in present-day species (such as human arms and bat wings).
- **Option C:** Analogous organs perform similar functions but have distinct evolutionary origins (such as bird wings and butterfly wings).
- **Option D:** Embryonic organs are transient developmental structures in embryos, not reduced ancestral organs.

Question #17 Key: (B)BIOLOGY
07. Circulation / Transport

The descending aorta is bifurcated into two vessels, which further divide into the femoral arte...

CORE CONCEPT & DERIVATION

The systemic arterial tree terminates its abdominal descent by bifurcating into the principal supply vessels of the pelvis and lower limbs.

Formula / Rule / Reaction:

Abdominal Aorta $\xrightarrow{\text{Bifurcation at L4}}$ Common Iliac Arteries $\rightarrow$ External Iliac Artery $\rightarrow$ Femoral Artery

Solution:

- At the level of the fourth lumbar vertebra (L4), the abdominal descending aorta bifurcates into the right and left common iliac arteries.
- Each common iliac artery divides into internal and external iliac arteries; the external iliac passes beneath the inguinal ligament to continue into the thigh as the femoral artery.

Why other options are incorrect:

- Option A:** The iliac vein returns deoxygenated blood from the legs to the inferior vena cava; it does not branch from the aorta.
- Option C:** The temporal artery supplies the scalp and head, branching from the external carotid artery.
- Option D:** The sciatic artery is an embryonic vessel largely replaced in adults by the femoral system.

Question #18 Key: (D)BIOLOGY
07. Circulation / Transport

The final destination of lymph is:

CORE CONCEPT & DERIVATION

The lymphatic system collects excess interstitial fluid from tissues and returns it into the venous bloodstream.

Formula / Rule / Reaction:

Interstitial Fluid $\rightarrow$ Lymph Vessels $\rightarrow$ Thoracic / Right Lymphatic Duct $\rightarrow$ Subclavian Veins

Solution:

- Lymph flows through lymphatic vessels, passing through filtering lymph nodes, into two main collecting ducts: the thoracic duct and the right lymphatic duct.
- These large ducts empty directly into the venous circulation at the junctions of the internal jugular and subclavian veins, returning fluid to the cardiovascular circuit.

Why other options are incorrect:

- Option A:** Lymph nodes are intermediate biological filter stations, not the terminal drainage site of lymph.
- Option B:** Lymphoid organs (spleen, thymus) facilitate lymphocyte maturation and immune defense, not terminal vascular drainage.
- Option C:** Lymph capillaries are the initial points of origin where interstitial fluid enters the system.

Question #19 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

The ABO blood group is controlled by more than two alleles in a population. This shows that the...

CORE CONCEPT & DERIVATION

When a single genetic locus exhibits three or more alternative allelic forms across a population, the gene is governed by multiple allelism.

Formula / Rule / Reaction:

Gene *I* alleles : I^A, I^B, i

Solution:

- The human ABO blood group system is encoded by the single gene *I* on chromosome 9, which exists in three primary allelic states: I^A , I^B , and *i*.
- Because three distinct alleles exist in the gene pool (even though any diploid individual inherits only two), it is a classic example of multiple alleles.

Why other options are incorrect:

- Option A:** Polygenic inheritance refers to a continuous phenotypic trait regulated by multiple independent genes at different loci (such as human skin color and height).
- Option C:** Operons are transcriptional units of coordinated gene clusters found in prokaryotes.
- Option D:** Allelic interaction is a generic term describing dominance or codominance, but the specific existence of more than two alleles is multiple allelism.

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

According to Mendel's Law of Segregation, one individual out of four in the F₂ generation had a...

CORE CONCEPT & DERIVATION

Recessive alleles remain masked in heterozygous states and only manifest phenotypically when homozygous in subsequent generations.

Formula / Rule / Reaction:

$P_1 : TT \times tt \rightarrow F_1 : Tt$ (All dominant) $\xrightarrow{\text{Selfing}}$ $F_2 : 1TT : 2Tt : 1tt$ (3 dominant : 1 recessive)

Solution:

- When pure-breeding dominant (*TT*) and recessive (*tt*) parents are crossed, the *F*₁ generation displays only the dominant phenotype because the recessive allele is masked.
- Upon self-fertilization of the *F*₁ hybrids, the alleles segregate so that 1 out of 4 (25%) offspring in the *F*₂ generation displays the recessive phenotype that failed to express in the *F*₁ generation.

Why other options are incorrect:

- Option B:** The recessive trait explicitly expresses in the *F*₂ generation in a 3:1 phenotypic ratio.
- Option C:** The *F*₂ generation is produced by subsequent breeding and is not the generation where the trait was masked.
- Option D:** The *P*₁ (parental) generation clearly expressed the recessive phenotype in the homozygous parent.

Question #21 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

A test cross is made to check the genotype of a trait. Which of the following crosses is a test...

CORE CONCEPT & DERIVATION

A test cross is an experimental breeding cross designed to reveal the zygosity of an individual displaying a dominant phenotype.

Formula / Rule / Reaction:

Test Cross = Individual of dominant phenotype (genotype unknown: TT or Tt) $\times$ Homozygous recessive individual (tt)

Solution:

- To determine whether an individual showing the dominant trait is homozygous dominant (TT) or heterozygous (Tt), it is mated with an individual carrying the homozygous recessive genotype (tt).
- If all progeny exhibit the dominant trait, the unknown is TT ; if a 1:1 phenotypic ratio appears, the unknown is Tt . Thus, "Unknown $\times$ tt " represents the test cross.

Why other options are incorrect:

- Option A:** "At" is non-standard genetic notation and does not represent a homozygous recessive tester.
- Option C:** "AB" represents codominant alleles or different loci rather than a homozygous recessive parent.
- Option D:** Crossing with a homozygous dominant individual (TT) is a backcross that would produce 100% dominant phenotypes regardless of the unknown genotype.

Question #22 Key: (B)BIOLOGY
11. Support & Movement

During the sliding of actin filaments, ATP is used for?

CORE CONCEPT & DERIVATION

In the cross-bridge cycle of skeletal muscle contraction, binding of ATP to the myosin head allosterically reduces its affinity for actin, causing detachment.

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

- Following the power stroke, the myosin head remains tightly bound to actin in a state of rigor.
- The binding of a fresh ATP molecule to the nucleotide-binding pocket of myosin causes a conformational change that breaks the cross-bridge.
- Subsequent ATP hydrolysis (to $\text{ADP} + \text{P}_i$) re-cocks the head for the next power stroke.

Why other options are incorrect:

- Option A:** Cross-bridge formation occurs spontaneously once calcium exposes the tropomyosin-blocked binding sites on actin, provided the myosin head is already energized.
- Option C:** Dragging the filaments (power stroke) is driven by the release of inorganic phosphate (P_i) and stored mechanical energy, not direct ATP binding.
- Option D:** Myofilaments themselves do not shorten; actin and myosin simply slide past one another.

Question #23 Key: (B)BIOLOGY
11. Support & Movement

The cell membrane of a muscle cell is:

CORE CONCEPT & DERIVATION

Muscle fibers have specialized anatomical nomenclature for their standard eukaryotic cellular components.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The plasma membrane enclosing a muscle fiber (myocyte) is termed the sarcolemma.
- The sarcolemma extends invaginations into the fiber called transverse tubules (T-tubules), which propagate electrical impulses into the interior of the cell.

Why other options are incorrect:

- Option A:** Sarcoplasm is the specialized cytoplasm of the muscle fiber, containing high amounts of glycogen and myoglobin.
- Option C:** A sarcomere is the contractile repeating unit bounded by two consecutive Z-lines within a myofibril.
- Option D:** Myofibrils are cylindrical organelles within the sarcoplasm made up of bundled actin and myosin myofilaments.

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

Irregular striation and involuntary control is related to:

CORE CONCEPT & DERIVATION

Muscle tissues differ in their histology, contractile unit organization, and autonomic regulation.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Cardiac muscle cells (cardiomyocytes) are striated because their actin and myosin are organized into sarcomeres.
- However, because the cells are branched and interconnected by intercalated discs with gap junctions, their striations appear irregular compared to skeletal muscle.
- Their contractions are myogenic and under involuntary autonomic control.

Why other options are incorrect:

- Option A:** Smooth muscle cells are involuntary but completely lack striations (non-striated).
- Option C:** Skeletal muscle cells exhibit regular, parallel, uniform striations and are under voluntary somatic control.
- Option D:** Fibroelastic cartilage is a skeletal connective tissue, not a contractile muscle tissue.

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

Cartilage is a type of what tissue?

CORE CONCEPT & DERIVATION

Cartilage is classified as a specialized supportive skeletal connective tissue.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Connective tissues are characterized by cells dispersed widely within an extensive extracellular matrix containing fibers and ground substance.
- In cartilage, chondrocytes reside in small spaces called lacunae within a firm, resilient matrix composed of chondroitin sulfate and collagen or elastic fibers.

Why other options are incorrect:

- Option B:** Epithelial tissue consists of tightly packed cells lining surfaces, cavities, and forming glands.
- Option C:** Muscular tissue is specialized for contraction and generating mechanical force.
- Option D:** Nervous tissue is composed of neurons and neuroglia specialized for electrical communication.

Question #26 Key: (D)BIOLOGY
13. Chemical Coordination

Production of follicle-stimulating hormone (FSH) and luteinizing hormone (LH) from the pituitary...

CORE CONCEPT & DERIVATION

Anterior pituitary gonadotropin secretion is governed by the hypophyseal-portal axis driven by neurohormonal output from the hypothalamus.

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

- The hypothalamus secretes Gonadotropin-Releasing Hormone (GnRH) in a pulsatile manner into the hypophyseal portal system.
- GnRH binds to receptors on pituitary gonadotrophs, stimulating the synthesis and exocytosis of both follicle-stimulating hormone (FSH) and luteinizing hormone (LH).

Why other options are incorrect:

- Option A:** The ovary responds to FSH and LH, exerting feedback control, but primary neuroendocrine synthesis and release is governed by the hypothalamus.
- Option B:** The uterus is a target tissue for ovarian steroids (estrogen and progesterone), having no direct endocrine control over pituitary gonadotropin production.
- Option C:** Stimulated ovarian follicles secrete estrogen, which provides feedback modulation, but the primary regulatory hormone driving production is GnRH from the hypothalamus.

Question #27 Key: (C)BIOLOGY
14. Reproduction

The term menopause means:

CORE CONCEPT & DERIVATION

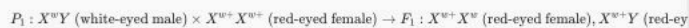
Menopause is the physiological cessation of ovarian folliculogenesis and cyclic menstrual activity in human females.

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

- With advancing age (typically between 45 and 52 years), the primordial follicle reserve of the ovaries becomes depleted.
- As a result, the cyclic maturation and ovulation of ova cease, estrogen levels fall, and the monthly menstrual cycle stops permanently.

Why other options are incorrect:

- Option A:** The initial onset and first occurrence of menstruation during puberty is termed menarche.
- Option B:** The onset of ovulation marks sexual maturity during puberty, not menopause.
- Option D:** Although the ovaries undergo follicular atresia and sclerosis, menopause is defined functionally by the cessation of ovulation and menstrual cycles.

Question #28 Key: (A)BIOLOGY
15. Inheritance / Variation & GeneticsTo study sex linkages in *Drosophila*, Morgan mated white-eyed males with wild-type red-eyed fema...**CORE CONCEPT & DERIVATION**Eye color in *Drosophila melanogaster* is an X-linked trait where the wild-type red-eye allele (X^{w+}) is dominant to the mutant white-eye allele (X^w).**Formula / Rule / Reaction:****Solution:**

- The homozygous red-eyed female produces only X^{w+} gametes.
- The hemizygous white-eyed male produces X^w and Y gametes.
- All female offspring inherit X^{w+} from the mother and X^w from the father, yielding heterozygous red-eyed females ($X^{w+}X^w$).
- All male offspring inherit X^{w+} from the mother and the Y chromosome from the father, yielding hemizygous red-eyed males ($X^{w+}Y$). Thus, 100% of the F_1 offspring have red eyes.

Why other options are incorrect:

- Option B:** White-eyed males appear in the F_1 only if the reciprocal cross is performed (white-eyed female $\times$ red-eyed male).
- Option C:** White-eyed females require two X^w alleles, which is impossible when the mother is homozygous wild-type.
- Option D:** No white-eyed offspring are produced in this cross because the maternal X^{w+} allele dominates in all progeny.

Question #29 Key: (B)BIOLOGY
06. Digestion/Nutrition

Enteron is the characteristic feature of:

CORE CONCEPT & DERIVATION

Phylum Cnidaria (Coelenterata) is characterized by a central sac-like gastrovascular cavity possessing a single opening serving as both mouth and anus.

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

- Cnidarians possess a central body cavity called the coelenteron or enteron (gastrovascular cavity).
- Extracellular digestion initiates within this cavity through secreted digestive enzymes, followed by intracellular phagocytosis by gastrodermal cells.

Why other options are incorrect:

- Option A:** Sponges (Porifera) lack any digestive enteron; water circulates through a system of ostia, a spongocoel, and an osculum, using intracellular digestion.
- Option C:** Flatworms (Platyhelminthes) possess a branched, blind-ending gut, but the characteristic enteron names Phylum Coelenterata (Cnidaria).
- Option D:** Echinoderms possess a complete digestive tract with a separate mouth and anus, and a true coelom.

Question #30 Key: (C)BIOLOGY
02. Biomolecules*The body of which is called metamerically segmented?***CORE CONCEPT & DERIVATION**

Metamerism is the linear division of the animal body into a series of repeating homologous segments (metameres) separated internally by septa.

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

- Phylum Annelida (such as the earthworm and leech) displays true metameric segmentation.
- Both external rings (annuli) and internal transverse intersegmental septa divide the body, repeating blood vessels, nerves, nephridia, and locomotory setae across segments.

Why other options are incorrect:

- **Option A:** Cnidarians are unsegmented diploblastic organisms exhibiting radial symmetry.
- **Option B:** Nematodes (roundworms) are unsegmented pseudocoelomates covered by a smooth cuticle.
- **Option D:** Sponges (Porifera) are asymmetrical, parazoan organisms lacking true tissues and segmentation.

Question #31 Key: (B)BIOLOGY
10. Homeostasis*Excretion in Planaria takes place by?***CORE CONCEPT & DERIVATION**

Flatworms possess a closed tubular excretory network terminating internally in specialized blind-ended ciliated bulbs.

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

- The excretory and osmoregulatory system of *Planaria* consists of two lateral branching networks of tubules called protonephridia.
- Capped at their blind ends by flame cells, the beating of their flagellar tufts drives interstitial fluid into the tubules, absorbing ions and releasing dilute waste through nephridiopores.

Why other options are incorrect:

- **Option A:** Malpighian tubules are excretory organs characteristic of terrestrial arthropods (insects and arachnids).
- **Option C:** Metanephridia are open, vascularized nephric tubules with ciliated nephrostomes found in annelids.
- **Option D:** Nephrons are the functional microscopic excretory units of the vertebrate kidney.

Question #32 Key: (C)BIOLOGY
10. Homeostasis*A four-chambered heart with a right systemic arch only is present in?***CORE CONCEPT & DERIVATION**

Vertebrate aortic arches undergo selective evolutionary regression, leaving birds with a persistent right systemic arch and mammals with a persistent left arch.

Formula / Rule / Reaction:
$$\text{Birds} = 4\text{-chambered heart} + \text{Right systemic arch only}$$
$$\text{Mammals} = 4\text{-chambered heart} + \text{Left systemic arch only}$$
Solution:

- Both birds (Aves) and mammals have completely separated four-chambered hearts (two atria and two ventricles).
- During embryonic aortic arch development, birds retain only the fourth right aortic arch as their systemic trunk, whereas mammals retain only the left arch.

Why other options are incorrect:

- **Option A:** Amphibians possess a three-chambered heart (two atria and one ventricle) with paired systemic arches.
- **Option B:** Most reptiles have an incompletely divided three-chambered heart with bilateral systemic arches (except crocodilians, which retain both arches connected by the foramen of Panizza).
- **Option D:** Mammals possess a four-chambered heart with a left systemic arch only.

Question #33 Key: (D)BIOLOGY
07. Circulation / Transport*The movement of water to a lower solute concentration area through a semipermeable membrane is?***CORE CONCEPT & DERIVATION**

Water moves across a selectively permeable membrane down a water potential gradient, a process fundamentally governed by solute potential.

Formula / Rule / Reaction:

$$\Psi_w = \Psi_s + \Psi_p \quad (\text{where } \Psi_s = -\pi)$$

Solution:

- Solute potential (Ψ_s) represents the reduction in water potential caused by dissolved solute particles.
- Pure water has a solute potential of 0; adding solutes makes it negative. Water movement across a semipermeable membrane is driven by differences in solute concentration, which dictate the solute potential gradient.
- **Note on Board Key:** In the official UHS paper, this question was keyed as D (Solute potential), reflecting the solute-concentration dependent driving force. Note that under physiological terms, osmotic potential is numerically equivalent to solute potential.

Why other options are incorrect:

- **Option A:** While osmotic potential is an equivalent biological term, the provincial examination curriculum keyed solute potential (Ψ_s) for this question.
- **Option B:** Pressure potential (Ψ_p) refers to mechanical hydrostatic pressure (turgor) exerted on the wall, not solute-directed movement.
- **Option C:** Soil potential is an ecological measure of total soil moisture forces, irrelevant to cell membrane dynamics.

Question #34 Key: (A)BIOLOGY
07. Circulation / Transport

The _____ describes how water and dissolved chemicals are carried through the cell wall ...

CORE CONCEPT & DERIVATION

Water and dissolved minerals travel across plant root tissues via distinct anatomical pathways: apoplastic, symplastic, and vacuolar.

Formula / Rule / Reaction:

Apoplast pathway = Continuous network of porous cell walls + Intercellular spaces

Solution:

- The apoplast pathway involves non-living structural spaces of the plant body, specifically the primary cell walls and intercellular gaps.
- Water moves rapidly through this porous matrix by capillary action and bulk flow without crossing the plasma membrane until reaching the hydrophobic Casparian strips of the endodermis.

Why other options are incorrect:

- Option B:** The symplast pathway consists of the interconnected system of living protoplasts linked via plasmodesmata.
- Option C:** The vacuolar pathway involves water moving from one cell vacuole to another across tonoplasts and plasma membranes.
- Option D:** Cytoplasmic theory is an obsolete term referring generically to intracellular movements rather than extracellular wall transport.

Question #35 Key: (B)BIOLOGY
06. Digestion/Nutrition

Feeding by living in or on the other organism (host) belonging to different species is called?

CORE CONCEPT & DERIVATION

Heterotrophic nutrition includes specialized symbiotic modes categorized according to nutritional dependency and impact on the host.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Parasitic nutrition is a symbiotic relationship in which one organism (the parasite) lives on the surface (ectoparasite) or within the tissues (endoparasite) of another living species (the host).
- The parasite derives organic nourishment and shelter while causing physiological harm or disease to the host.

Why other options are incorrect:

- Option A:** Mineral nutrition describes the uptake and assimilation of inorganic ions by autotrophic plant roots from the soil.
- Option C:** Saprophytic nutrition involves absorbing soluble organic compounds from dead, decaying matter via extracellular digestion.
- Option D:** Symbiotic nutrition is a broad term that typically implies mutualism, where both species benefit, unlike unilateral parasitism.

Question #36 Key: (C)BIOLOGY
05. Acellular Life

Which of the following viruses contains single-stranded DNA?

CORE CONCEPT & DERIVATION

Under the Baltimore virus classification, viral genomes are distinguished based on strandedness (single vs. double) and nucleic acid type (DNA vs. RNA).

Formula / Rule / Reaction:

Baltimore Group II = ssDNA viruses (e.g., Parvoviridae)

Solution:

- Parvoviruses are tiny, non-enveloped icosahedral viruses carrying a linear single-stranded DNA (ssDNA) genome of roughly 5 kilobases.
- Upon infection, the viral ssDNA is converted into a double-stranded intermediate inside the host nucleus before transcription.

Why other options are incorrect:

- Option A:** Adenoviruses are non-enveloped double-stranded DNA (dsDNA) viruses.
- Option B:** Herpesviruses are large, enveloped double-stranded DNA (dsDNA) viruses.
- Option D:** Poxviruses are complex, enveloped double-stranded DNA (dsDNA) viruses.

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

Which one of the following is an X-linked dominant disorder?

CORE CONCEPT & DERIVATION

X-linked dominant disorders manifest in both hemizygous males and heterozygous females carrying a single mutant allele on the X chromosome.

Formula / Rule / Reaction:X-linked dominant : $X^D X^d$ (Affected female), $X^D Y$ (Affected male)**Solution:**

- Hypophosphatemic rickets (vitamin D-resistant rickets) is caused by mutations in the *PHEX* gene on the X chromosome.
- Because it is inherited in an X-linked dominant fashion, affected fathers transmit the trait to 100% of their daughters and 0% of their sons, while heterozygous mothers transmit it to 50% of all offspring.

Why other options are incorrect:

- Option A:** Hemophilia (A and B) is an X-linked recessive bleeding disorder.
- Option B:** Red-green color blindness is an X-linked recessive visual pigment deficiency.
- Option D:** Becker muscular dystrophy is an X-linked recessive dystrophin gene defect.

Question #38 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics*Only those genes can assort independently whose loci are on:***CORE CONCEPT & DERIVATION**

Mendel's Law of Independent Assortment applies strictly to genes that are unlinked, meaning their loci reside on different, non-homologous pairs of chromosomes.

Formula / Rule / Reaction:

Recombination frequency = 50% $\Rightarrow$ Independent assortment between non-homologous chromosomes

Solution:

- During Anaphase I of meiosis, the orientation and segregation of one bivalent (homologous chromosome pair) occurs completely at random relative to any other non-homologous bivalent.
- Consequently, alleles located on non-homologous chromosomes segregate independently into gametes.

Why other options are incorrect:

- **Option A:** Genes on the same chromatid are physically linked and tend to be inherited together as a linkage group.
- **Option B:** Genes on the same chromosome are syntenic and exhibit genetic linkage, violating independent assortment unless separated by crossing over.
- **Option D:** Homologous chromosomes carry alleles of the exact same gene loci at corresponding positions, not independent gene pairs.

Question #39 Key: (D)BIOLOGY
09. Respiration / Gaseous Exchange*Smooth muscles are found in all the mentioned below except:***CORE CONCEPT & DERIVATION**

The conduction zone of the respiratory tract contains involuntary smooth muscle in its walls, whereas the respiratory exchange surfaces are specialized single-cell epithelial layers.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The walls of the trachea, bronchi, and bronchioles possess smooth muscle fibers (such as the trachealis muscle and bronchiolar muscularis) that regulate airway diameter and resistance.
- Alveoli are thin-walled terminal air sacs lined exclusively by simple squamous epithelium (Type I pneumocytes) and secretory cells (Type II pneumocytes) supported by elastic basement membranes; they contain no smooth muscle.

Why other options are incorrect:

- **Option A:** The posterior gap of the C-shaped cartilage in the trachea contains the smooth trachealis muscle.
- **Option B:** Bronchi contain interlacing bands of smooth muscle between their cartilaginous plates.
- **Option C:** Bronchioles lack cartilage and are surrounded by a prominent layer of smooth muscle capable of bronchoconstriction.

Question #40 Key: (B)BIOLOGY
09. Respiration / Gaseous Exchange*The method of bringing oxygenated air into contact with a gas exchange surface is called:***CORE CONCEPT & DERIVATION**

Ventilation (breathing) is the physical, mechanical process that moves the respiratory medium over the respiratory surface.

Formula / Rule / Reaction:

Ventilation = Inhalation (Bulk flow in) + Exhalation (Bulk flow out)

Solution:

- Ventilation is the mechanical bulk flow of environmental air or water across a specialized gas exchange surface (such as alveoli or gills).
- This continuous bulk flow maintains steep partial pressure gradients of oxygen and carbon dioxide, facilitating efficient passive diffusion.

Why other options are incorrect:

- **Option A:** Photorespiration is a light-dependent, wasteful metabolic process in C_3 plants where RuBisCO fixes O_2 instead of CO_2 .
- **Option C:** Gaseous transport is the circulatory movement of oxygen and carbon dioxide in the blood between the lungs and systemic tissues.
- **Option D:** Cellular respiration refers to intracellular biochemical catabolism generating ATP from glucose in mitochondria.

Question #41 Key: (A)BIOLOGY
01. Cell*The number of layers of the cell wall in Gram-positive bacteria is:***CORE CONCEPT & DERIVATION**

Bacterial cell envelope architecture differs fundamentally between Gram-positive and Gram-negative taxa.

Formula / Rule / Reaction:

Gram-positive envelope = 1 single thick peptidoglycan wall layer + 1 plasma membrane

Solution:

- According to the Punjab Textbook of Biology, Gram-positive bacteria possess a single, continuous, thick layer of peptidoglycan (20 to 80 nm) exterior to the cell membrane.
- In contrast, Gram-negative bacteria possess two distinct layers: an inner thin peptidoglycan layer and an outer membrane rich in lipopolysaccharides.

Why other options are incorrect:

- **Option B:** Two wall layers is the characteristic hallmark of Gram-negative bacteria (thin peptidoglycan plus an outer membrane).
- **Option C:** Three layers is an incorrect anatomical description of standard bacterial cell walls.
- **Option D:** Four layers is not found in eubacterial cell wall classifications.

Question #42 Key: (C)BIOLOGY
05. Acellular Life*Helicobacter pylori* is an example of:**CORE CONCEPT & DERIVATION**

Certain bacteria display morphological adaptability, altering their cellular geometry between curved helical rods and spherical forms in response to environmental conditions.

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

- ***Helicobacter pylori*** is a microaerophilic gastric pathogen that typically adopts a curved, spiral-helical rod form during active infection.
- However, under physiological stress, antibiotic pressure, or prolonged culture, it undergoes morphological conversion into a viable but non-culturable coccoid form.
- Because it exists in both helical and coccoid morphologies, the official provincial curriculum and answer key classify it as pleomorphic.

Why other options are incorrect:

- **Option A:** Cocci are strictly spherical bacteria that do not form active helical rods.
- **Option B:** Bacilli are straight, rod-shaped bacteria (such as *Escherichia coli** or *Bacillus subtilis**).
- **Option D:** While morphologically helical in fresh tissue, the board keys **H. pylori** as pleomorphic due to its prominent transformation into coccoid bodies.

Question #43 Key: (A)BIOLOGY
01. Cell*Bacterial cells can maintain their shape through:***CORE CONCEPT & DERIVATION**

The bacterial cell wall provides structural rigidity and protects the cell against osmotic lysis.

Formula / Rule / Reaction:

Peptidoglycan (Murein) = Alternating NAG-NAM glycan chains cross-linked by tetrapeptide chains

Solution:

- The rigid peptidoglycan meshwork forms a sacculus surrounding the bacterium.
- This structure withstands internal osmotic turgor pressure (often reaching 2 to 20 atmospheres) and dictates the characteristic morphological shape (coccus, bacillus, spirillum) of the bacterial cell.

Why other options are incorrect:

- **Option B:** The capsule is a protective polysaccharide layer exterior to the wall that provides virulence and prevents phagocytosis, not cell shape.
- **Option C:** Slime is a loose, diffuse, unorganized glycocalyx aiding in surface adhesion, having no rigid structural role in maintaining cell shape.
- **Option D:** Slime alone provides no tensile strength against osmotic bursting or deformation.

Question #44 Key: (B)BIOLOGY
17. Biotechnology*Which of the following is an example of spiral-shaped bacteria?***CORE CONCEPT & DERIVATION**

Bacterial morphological classifications group organisms by their characteristic vegetative shapes (spherical, rod-like, or curved/spiral).

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

- According to the Punjab Textbook of Biology, **Hyphomicrobium** is classified alongside prosthecate and budding prosthecate-forming bacteria exhibiting curved and spirally twisted morphologies.
- It is listed in the provincial curriculum as an example within the spiral and prosthecate morphotype category.

Why other options are incorrect:

- **Option A:** **Diplococcus pneumoniae** (**Streptococcus pneumoniae**) forms pairs of spherical cocci.
- **Option C:** **Escherichia coli** is a straight, rod-shaped bacterium (bacillus).
- **Option D:** **Pseudomonas** is a straight or slightly curved rod-shaped bacterium, not a true spiral.

Question #45 Key: (A)BIOLOGY
17. Biotechnology*All the following are disinfectants to control bacterial growth except:***CORE CONCEPT & DERIVATION**

Antimicrobial chemical agents are categorized by their application site: antiseptics are applied safely to living tissue, whereas disinfectants are applied to inanimate objects.

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

- Tincture of iodine (elemental iodine dissolved in ethanol and water) is specifically formulated as an antiseptic for skin cleansing and wound disinfection.
- In contrast, mercuric chloride, potassium permanganate solutions, and concentrated hydrogen peroxide are traditionally employed as disinfectants on inanimate instruments and surfaces.

Why other options are incorrect:

- **Option B:** Potassium permanganate is widely used as an oxidizing chemical disinfectant for water and equipment.
- **Option C:** Mercuric chloride is a heavy-metal disinfectant used to sanitize laboratory surfaces and surgical hardware.
- **Option D:** Hydrogen peroxide acts as a high-level disinfectant for inanimate clinical equipment and surfaces.

Question #46 Key: (A)BIOLOGY
14. Reproduction*The function of hyaluronidase enzyme is:***CORE CONCEPT & DERIVATION**

The acrosome of a mature spermatozoon contains specialized hydrolytic enzymes designed to disperse the cellular barriers enclosing the secondary oocyte.

Formula / Rule / Reaction:

Hyaluronidase + Hyaluronic acid (intercellular cement of corona radiata) → Enzymatic dispersion

Solution:

- The secondary oocyte is enveloped by follicle cells embedded in an intercellular matrix rich in hyaluronic acid (the corona radiata).
- During the acrosome reaction, the sperm releases hyaluronidase, which hydrolyzes the hyaluronic acid polymers, allowing the sperm to penetrate through the corona radiata and reach the zona pellucida.

Why other options are incorrect:

- **Option B:** Sperm enters the vaginal canal through mechanical ejaculation, not enzymatic dissolution.
- **Option C:** Sperm passage into the fallopian tubes is driven by flagellar motility and uterine muscular contractions.
- **Option D:** Sperm that fail to fertilize undergo phagocytosis by uterine and fallopian leukocytes, not self-inactivation by hyaluronidase.

Question #47 Key: (A)BIOLOGY
14. Reproduction*In human females, what is the small, pear-shaped, muscular, distensible, sac-like organ where g...***CORE CONCEPT & DERIVATION**

Gestation (prenatal development) requires a specialized muscular organ capable of nutrient exchange, fetal protection, and expansion.

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

- The uterus (womb) is a hollow, pear-shaped, thick-walled muscular organ situated in the female pelvic cavity between the urinary bladder and rectum.
- Its inner vascular lining (endometrium) supports blastocyst implantation and placenta formation, while its muscular layer (myometrium) expands during pregnancy to accommodate the growing fetus throughout gestation.

Why other options are incorrect:

- **Option B:** The kidney is an excretory organ responsible for blood filtration, osmoregulation, and urine production.
- **Option C:** The fallopian tube (oviduct) is the conduit where fertilization typically occurs, but embryonic gestation takes place in the uterus.
- **Option D:** The stomach is a digestive organ located in the abdominal cavity responsible for acid breakdown of food.

Question #48 Key: (B)BIOLOGY
14. Reproduction*The labour pains to expel fetus are due to action of oxytocin on:***CORE CONCEPT & DERIVATION**

Parturition involves a neuroendocrine positive feedback loop where oxytocin directly stimulates forceful contractions of the uterine smooth muscle.

Formula / Rule / Reaction:

Ferguson reflex : Cervical stretch → Oxytocin release → Myometrial contraction → Increased stretch

Solution:

- The uterine wall consists of three histological layers: outer perimetrium, middle muscular myometrium, and inner glandular endometrium.
- Oxytocin acts directly on G-protein coupled oxytocin receptors on the smooth muscle cells of the myometrium, opening voltage-gated calcium channels and causing the powerful, rhythmic contractions perceived as labor pains.

Why other options are incorrect:

- **Option A:** The endometrium is the mucosal lining that forms the maternal portion of the placenta; it does not contain contractile smooth muscle.
- **Option C:** The perimetrium is the outer serous peritoneal covering of the uterus with no contractile role.
- **Option D:** The ovaries produce female gametes and steroid hormones, playing no mechanical role in expelling the fetus during labor.

Question #49 Key: (B)BIOLOGY
05. Acellular Life*A virus is what type of agent?***CORE CONCEPT & DERIVATION**

Viruses are non-cellular, sub-microscopic biological entities consisting of a nucleic acid genome encased within a protein capsid.

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

- Viruses are obligate intracellular infectious agents capable of replication solely within permissive living host cells.
- They cause infections across all forms of life, including animals, plants, fungi, and bacteria.

Why other options are incorrect:

- **Option A:** Viruses are strictly acellular; they lack cytoplasm, organelles, and a metabolic plasma membrane.
- **Option C:** Viruses are inherently infectious agents capable of horizontal and vertical transmission.
- **Option D:** All natural viruses possess a proteinaceous shell (capsid), and many contain viral enzymes; they are not non-protein agents.

Question #50 Key: (A)BIOLOGY
08. Immunity

The molecules used to control viruses during infection of animal cells are:

CORE CONCEPT & DERIVATION

Host cells infected by viruses produce and secrete signaling glycoproteins called interferons that establish an antiviral state in neighboring uninfected cells.

Formula / Rule / Reaction:

Viral RNA/DNA → Host cell secretes IFN → Neighboring cell activates 2',5'-oligoadenylate synthetase and PKR → Inhibition of viral translation

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase (yeast)}} 2C_2H_5OH + 2CO_2 \uparrow + 2ATP$$
Solution:

- Interferons (type I IFN- α and IFN- β) are cytokines released by animal cells in response to viral invasion.
- They bind to surface receptors on adjacent cells, signaling them to synthesize antiviral proteins that inhibit protein synthesis and degrade viral mRNA, limiting the spread of infection.

Why other options are incorrect:

- **Option B:** Histones are basic nuclear proteins that package and condense eukaryotic genomic DNA into nucleosomes.
- **Option C:** An antigen is a foreign molecular structure that elicits an immune response, not an endogenous defensive signaling molecule.
- **Option D:** Serum is the liquid, non-cellular component of coagulated blood, not a specific antiviral molecule.

Question #51 Key: (D)BIOLOGY
05. Acellular Life

The provirus of HIV is structurally and chemically made up of:

CORE CONCEPT & DERIVATION

A provirus is the genomic form of a retrovirus that has integrated directly into the host cell nuclear chromosome.

Formula / Rule / Reaction:

Viral ssRNA $\xrightarrow{\text{Reverse Transcriptase}}$ cDNA/RNA hybrid $\xrightarrow{\text{DNA Polymerase}}$ dsDNA $\xrightarrow{\text{Integrase}}$ Provirus (integrated dsDNA)

Solution:

- The mature human immunodeficiency virus (HIV) virion enters the host CD4+ T-cell carrying two copies of positive-sense single-stranded RNA (ssRNA).
- Viral reverse transcriptase synthesizes a complementary minus strand of DNA and then a second plus strand to yield double-stranded DNA (dsDNA).
- This viral dsDNA migrates into the nucleus and is inserted into the host genome by viral integrase, establishing the latent provirus state.

Why other options are incorrect:

- **Option A:** ssRNA is the genomic format present inside the infective extracellular virion core, not the integrated provirus.
- **Option B:** ssDNA is an unstable transient intermediate formed during reverse transcription before second-strand synthesis.
- **Option C:** dsRNA is characteristic of Reoviruses and rotaviruses, playing no role in retroviral integration.

Question #52 Key: (D)BIOLOGY
04. Bioenergetics

Which of the following is used in baking?

CORE CONCEPT & DERIVATION

Baking relies on alcoholic fermentation carried out by yeast under anaerobic conditions to leaven dough.

Formula / Rule / Reaction:

$C_6H_{12}O_6 \xrightarrow{\text{Zymase (yeast)}} 2C_2H_5OH + 2CO_2 \uparrow + 2ATP$

Solution:

- *Saccharomyces cerevisiae* (baker's yeast) metabolizes flour sugars via anaerobic alcoholic fermentation (glycolysis followed by pyruvate decarboxylation and reduction).
- The released carbon dioxide gas forms bubbles trapped in the gluten network, causing the dough to rise and creating the porous texture of baked bread.

Why other options are incorrect:

- **Option A:** Aerobic respiration consumes oxygen completely and produces water and carbon dioxide without generating the rapid leavening action of anaerobic fermentation in dense dough.
- **Option B:** External respiration refers to physiological alveolar gas exchange between blood and environmental air in animals.
- **Option C:** Internal respiration refers to systemic capillary gas exchange between blood and peripheral tissue cells.

Question #53 Key: (A)BIOLOGY
04. Bioenergetics

Which is the major event in the electron transport chain?

CORE CONCEPT & DERIVATION

The mitochondrial electron transport chain couples exergonic electron transfers to proton pumping, establishing a proton motive force that drives oxidative phosphorylation.

Formula / Rule / Reaction:

$$ADP + P_i + H^+_{\text{intermembrane}} \xrightarrow{\text{ATP Synthase}} ATP + H_2O + H^+_{\text{matrix}}$$
Solution:

- High-energy electrons from NADH and FADH₂ traverse Complexes I through IV, releasing free energy used to pump protons into the intermembrane space.
- The primary physiological purpose and major culminating event of this pathway is ATP synthesis via chemiosmosis through F₀F₁-ATP synthase.

Why other options are incorrect:

- **Option B:** Substitution is an organic chemical reaction mechanism that does not describe respiratory electron flow.
- **Option C:** Decarboxylation occurs during pyruvate oxidation and the Krebs cycle, releasing carbon dioxide, not in the respiratory chain.
- **Option D:** Isomerization occurs during glycolysis (such as conversion of glucose-6-phosphate to fructose-6-phosphate) and the citric acid cycle.

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

Out of 36 ATPs, how many are produced in the electron transport chain?

CORE CONCEPT & DERIVATION

Total cellular respiration yields ATP through substrate-level phosphorylation and oxidative phosphorylation.

Formula / Rule / Reaction:

$$\text{Total ATP} = \text{Substrate-level phosphorylation} + \text{Oxidative phosphorylation (ETC)}$$

$$36 \text{ ATP} = 4 \text{ ATP (2 Glycolysis} + 2 \text{ Krebs)} + 32 \text{ ATP (ETC)}$$

Solution:

- Substrate-level phosphorylation yields a net of 2 ATP during glycolysis and 2 ATP (or GTP) during the Krebs cycle, for a total of 4 direct ATP.
- Subtracting the direct substrate-level yield from the classical textbook total of 36 ATP gives:

$$36 \text{ ATP} - 4 \text{ ATP} = 32 \text{ ATP}$$

Why other options are incorrect:

- Option A:** 28 ATP underestimates the oxidative phosphorylation yield derived from the reoxidation of 10 NADH and 2 FADH₂.
- Option B:** 30 ATP is the total theoretical yield calculated under modern P/O ratios (2.5 per NADH, 1.5 per FADH₂), not the ETC contribution in the 36-ATP model.
- Option D:** 34 ATP would represent the yield only if glycolysis consumed zero ATP in its preparatory phase and produced 38 total ATP.

Question #55 Key: (C)BIOLOGY
04. Bioenergetics

The major enzyme involved in the transfer of the phosphate group from ATP to glucose is:

CORE CONCEPT & DERIVATION

Kinases are transferase enzymes that catalyze the transfer of a gamma-phosphate group from a high-energy nucleoside triphosphate to a specific acceptor substrate.

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

- The initial priming step of glycolysis traps glucose inside the cell via phosphorylation at carbon-6.
- This exergonic reaction is catalyzed by hexokinase (in most tissues) or glucokinase (in hepatocytes), both of which belong to the kinase class of enzymes.

Why other options are incorrect:

- Option A:** Isomerases catalyze structural rearrangements converting a molecule into its isomeric form (such as phosphohexose isomerase).
- Option B:** Dehydrogenases catalyze redox reactions by transferring hydrides to electron acceptors like NAD⁺ or FAD.
- Option D:** Decarboxylases catalyze the non-oxidative or oxidative removal of a carboxyl group as carbon dioxide.

Question #56 Key: (A)BIOLOGY
02. Biomolecules

_____ forms almost three-fourth of the body by weight.

CORE CONCEPT & DERIVATION

Water is the universal biological solvent and quantitative solvent component of living protoplasm.

Formula / Rule / Reaction:

$$\text{Total Body Mass} \approx 65\% - 75\% \text{ Water (by weight)}$$

Solution:

- In typical animal tissues and adult humans, water constitutes approximately 70% to 75% (nearly three-fourths) of the total body weight.
- It provides the fluid medium for metabolic reactions, thermoregulation, and internal transport of solutes.

Why other options are incorrect:

- Option B:** Proteins constitute approximately 15% to 18% of total body weight, representing the second most abundant component.
- Option C:** Carbohydrates serve primarily as dynamic metabolic fuel, accounting for less than 1% to 2% of total human body weight.
- Option D:** Lipids account for approximately 10% to 20% of body mass depending on adiposity.

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

Energy is ----- by the breakdown of complex molecules into simpler ones; such reactions are c...

CORE CONCEPT & DERIVATION

Catabolism encompasses exergonic oxidative pathways in which complex macromolecules are degraded into smaller metabolites with a net release of free energy.

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

- Catabolic reactions (such as glycolysis, beta-oxidation, and proteolysis) break high-energy covalent chemical bonds.
- Because the products reside at a lower free-energy state than the reactants, free energy is released, much of which is captured in the terminal pyrophosphate bonds of ATP.

Why other options are incorrect:

- Option B:** Consuming energy is the characteristic definition of endergonic anabolic (synthetic) reactions.
- Option C:** Energy is absorbed in endothermic chemical transformations, whereas catabolic pathways produce a net release of enthalpy and Gibbs free energy.
- Option D:** Energy cannot be destroyed, adhering strictly to the First Law of Thermodynamics.

Question #58 Key: (B)BIOLOGY
02. Biomolecules

Biologically, it plays key roles in maintaining the integrity of lipid bilayer membranes:

CORE CONCEPT & DERIVATION

The spontaneous assembly and structural stability of biological membranes are driven predominantly by the hydrophobic effect in an aqueous environment.

Formula / Rule / Reaction:

$$\Delta G_{\text{assembly}} = \Delta H - T\Delta S \quad (\Delta S_{\text{water}} > 0 \Rightarrow \text{Hydrophobic driving force})$$

Solution:

- Phospholipids are amphipathic molecules containing hydrophilic heads and nonpolar hydrophobic fatty acyl tails.
- In an aqueous environment, water molecules form ordered clathrate cages around nonpolar hydrocarbon chains; aggregating the hydrophobic tails into the interior releases trapped water molecules, increasing the entropy of the system.
- These hydrophobic interactions maintain the structural integrity and self-sealing nature of the lipid bilayer.

Why other options are incorrect:

- Option A:** Hydrophilic exclusion is a non-standard descriptive term; the established thermodynamic phenomenon is hydrophobic exclusion or hydrophobic interaction.
- Option C:** Specific heat capacity buffers biological temperature fluctuations, having no direct mechanical role in stabilizing the lipid bilayer core.
- Option D:** Heat of vaporization governs evaporative cooling in living organisms.

Question #59 Key: (B)BIOLOGY
02. Biomolecules

The specific heat of vaporization of water plays an important role in the regulation of heat pr...

CORE CONCEPT & DERIVATION

Aerobic metabolism relies on the oxidation of carbohydrates and lipids, an exergonic process that generates metabolic heat dissipated through evaporative cooling.

Formula / Rule / Reaction:

$$\Delta H_{\text{vap (water)}} = 40.65 \text{ kJ/mol} \approx 2260 \text{ J/g (at } 100^\circ\text{C)}$$

Solution:

- According to the Punjab Textbook of Biology, the high latent heat of vaporization of water provides a stabilizing cooling mechanism for organisms.
- This property specifically prevents hyperthermia by dissipating excess thermal energy produced during cellular oxidation of respiratory substrates.

Why other options are incorrect:

- Option A:** Reduction reactions are anabolic or biosynthetic processes that consume reducing equivalents rather than generating excess metabolic heat.
- Option C:** While all oxidation is paired with reduction in overall redox chemistry, the textbook explicitly identifies oxidation as the primary heat-generating pathway.
- Option D:** Oxidation is the recognized curriculum answer.

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

Which type of bond must be broken for water to vaporize?

CORE CONCEPT & DERIVATION

Phase transitions from liquid to gas require overcoming the intermolecular attractive forces holding molecules together in the condensed phase.

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

- In liquid water, each molecule forms dynamic hydrogen bonds with neighboring molecules through electrostatic attractions between partially negative oxygen atoms and partially positive hydrogen atoms.
- Vaporization requires input of thermal energy to disrupt these intermolecular hydrogen bonds so that individual water molecules can escape into the vapor phase.
- Intramolecular polar covalent bonds (O – H) remain completely intact during physical vaporization.

Why other options are incorrect:

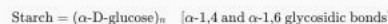
- Option A:** Water possesses polar covalent bonds, not nonpolar covalent bonds, and they are not broken during boiling.
- Option B:** Polar covalent intramolecular bonds between oxygen and hydrogen remain intact; breaking them would constitute chemical decomposition into elemental gases.
- Option D:** Pure liquid water does not contain an ionic lattice of ionic bonds.

Question #61 Key: (A)BIOLOGY
02. Biomolecules

Which statement is true regarding both starch and cellulose?

CORE CONCEPT & DERIVATION

Starch and cellulose are high-molecular-weight homopolysaccharides composed exclusively of repeating D-glucose subunits.

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

- Both starch and cellulose yield solely D-glucose upon complete acid-catalyzed hydrolysis.
- They differ in their glycosidic stereochemistry: starch utilizes $\alpha\text{-1,4}$ (and $\alpha\text{-1,6}$) linkages, whereas cellulose utilizes linear unbranched $\beta\text{-1,4}$ linkages.

Why other options are incorrect:

- Option B:** Geometric (cis-trans) isomerism occurs across restricted double bonds or rings, not between giant polysaccharide stereoisomers with different glycosidic linkages.
- Option C:** Humans possess $\alpha\text{-amylase}$ to digest starch, but lack cellulase to hydrolyze $\beta\text{-1,4-glycosidic}$ bonds, rendering cellulose indigestible dietary fiber.
- Option D:** Starch serves as the carbohydrate energy storage reserve in plants, whereas cellulose serves as the structural framework of the plant cell wall.

Question #62 Key: (B)BIOLOGY
02. Biomolecules

Most of the monosaccharides form a ring structure when in solution. For example, ribose will cr...

CORE CONCEPT & DERIVATION

In aqueous solution, pentoses and hexoses undergo intramolecular hemiacetal or hemiketal cyclization to form stable five- or six-membered cyclic hemiacetals.

Formula / Rule / Reaction:

Furanose = Five-membered ring containing 4 carbon atoms and 1 oxygen atom

Solution:

- D-ribose is an aldopentose that undergoes intramolecular nucleophilic addition of the C-4 hydroxyl group to the C-1 carbonyl carbon.
- This produces a five-membered cyclic hemiacetal termed ribofuranose, named by analogy to the heterocyclic parent compound furan.

Why other options are incorrect:

- **Option A:** Glucopyranose is the six-membered ring formed by the aldohexose D-glucose (5 carbons and 1 oxygen atom in the ring).
- **Option C:** Glyceraldehyde is an open-chain triose (3 carbons) that cannot form a stable internal cyclic ring.
- **Option D:** Acetaldehyde is a simple two-carbon aliphatic aldehyde (CH_3CHO).

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

Cyclosis and amoeboid movements are due to:

CORE CONCEPT & DERIVATION

Intracellular cytoplasmic streaming (cyclosis) and pseudopodial crawling are active processes generated by actin microfilaments interacting with myosin motor proteins.

Formula / Rule / Reaction:

Microfilament motor cycle : Actin filaments + Myosin + ATP → Cytoplasmic streaming / Sol-gel transitions

Solution:

- Microfilaments are thin, solid cytoskeletal polymers (roughly 7 nm diameter) composed of globular actin (G-actin) subunits.
- Dynamic polymerization and depolymerization of actin, coupled with myosin motor activity, generates the motive force responsible for cyclosis in plant cells and pseudopodial amoeboid movement in leukocytes and amoebae.

Why other options are incorrect:

- **Option A:** Microtubules (tubulin polymers) form the mitotic spindle and direct organelle transport along kinesin/dynein motors, but do not power cyclosis.
- **Option B:** Cilia are specialized axonemal surface organelles that move extracellular fluids or enable swimming, not intracellular streaming.
- **Option D:** Intermediate filaments provide structural tensile strength and prevent cellular deformation without direct contractile motor activity.

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

Proteins and lipids are modified into glycoproteins and glycolipids by which cell organelle?

CORE CONCEPT & DERIVATION

The Golgi apparatus is the primary subcellular sorting and processing station responsible for terminal glycosylation and conjugation of lipids and proteins.

Formula / Rule / Reaction:

Polypeptide / Lipid + Oligosaccharide precursor $\xrightarrow{\text{Golgi Glycosyltransferases}}$ Glycoprotein / Glycolipid

Solution:

- Proteins and lipids synthesized in the endoplasmic reticulum travel via transport vesicles to the *cis* face of the Golgi complex.
- Inside the cisternae, resident glycosyltransferase enzymes attach and remodel complex carbohydrate side chains, producing mature glycoproteins and glycolipids for secretion or membrane targeting.

Why other options are incorrect:

- **Option B:** The rough endoplasmic reticulum initiates N-linked core glycosylation of nascent polypeptides, but terminal remodeling and glycolipid conjugation take place in the Golgi.
- **Option C:** The smooth endoplasmic reticulum synthesizes neutral lipids, phospholipids, and steroids, but does not perform terminal glycosylation into glycolipids.
- **Option D:** Ribosomes synthesize raw polypeptide chains through translation; they possess no glycosylating enzymatic machinery.

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

Which structure of the prokaryotic cell will play the role of the mitochondrion?

CORE CONCEPT & DERIVATION

Prokaryotic cells lack membrane-bound organelles; respiratory enzymes are situated within the plasma membrane and its internal folded extensions.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Mesosomes are invaginations of the bacterial plasma membrane that increase the surface area for respiratory electron transport enzymes and ATP synthases.
- According to the Punjab Textbook of Biology, mesosomes carry out respiratory functions analogous to mitochondrial cristae in eukaryotic cells.

Why other options are incorrect:

- **Option A:** Endospores are dehydrated, cryptobiotic survival structures formed by bacteria under unfavorable environmental stress, not energy-generating organelles.
- **Option B:** Cysts are dormant, thick-walled protective stages found in certain bacteria and protozoa.
- **Option C:** The nucleoid is the irregularly shaped intracellular region containing the bacterial circular double-stranded DNA genome.

Question #66 Key: (B)BIOLOGY
01. Cell

The cell wall of a prokaryotic cell is composed of:

CORE CONCEPT & DERIVATION

The primary structural polymer of the eubacterial cell wall is peptidoglycan (murein), a macromolecular polymer of polysaccharide backbones cross-linked by peptide chains.

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

- Peptidoglycan consists of alternating amino sugars: N-acetylglucosamine (NAG) and N-acetylmuramic acid (NAM) joined by β -1,4-glycosidic bonds.
- These polysaccharide glycan chains are cross-linked by short amino acid oligopeptides (tetrapeptides). Thus, it is chemically composed of carbohydrates and amino acid peptides (proteins).
- Note on Board Key: While Option A ("Carbohydrates") was marked in some preliminary scoring keys, Option B ("Carbohydrates and Proteins") represents the comprehensive, biochemically accurate description of peptidoglycan specified in the provincial syllabus.

Why other options are incorrect:

- Option A:** Pure carbohydrate descriptions apply to plant cellulose or fungal chitin, neglecting the cross-linking peptide chains essential to peptidoglycan.
- Option C:** Proteins alone form the S-layer of certain archaea, but do not constitute the peptidoglycan cell wall of eubacteria.
- Option D:** Proteins and lipids form cell membranes, not the structural peptidoglycan sacculus.

Question #67 Key: (C)BIOLOGY
03. Enzymes

Competitive inhibitors stop an enzyme from working by:

CORE CONCEPT & DERIVATION

Competitive inhibition involves an inhibitor that reversibly binds directly within the catalytic active site cleft, preventing substrate entry.

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

- Because competitive inhibitors share structural similarity with the natural substrate, they fit directly into the binding and catalytic residues of the active site.
- By occupying the active site, the inhibitor physically blocks substrate molecules from accessing catalytic residues, halting product formation.

Why other options are incorrect:

- Option A:** Changing the shape of the enzyme via allosteric binding describes non-competitive or allosteric inhibition.
- Option B:** The inhibitor binds to the enzyme active site, not to the free substrate in solution.
- Option D:** Inhibitors do not exert regulation by binding the chemical products of the reaction.

Question #68 Key: (B)BIOLOGY
06. Digestion/Nutrition

After the digestion & before absorption, the product of the protein is:

CORE CONCEPT & DERIVATION

Complete luminal and brush-border enzymatic hydrolysis converts dietary proteins into absorbable monomeric units for enterocyte transport.

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

- Endopeptidases (pepsin, trypsin, chymotrypsin) and exopeptidases (carboxypeptidases, aminopeptidases) systematically hydrolyze internal and terminal peptide bonds.
- At the brush border and within the mucosal enterocytes, dipeptidases complete hydrolysis so that proteins are fully reduced to free amino acids before entry into the portal bloodstream.

Why other options are incorrect:

- Option A:** While dipeptides and tripeptides enter enterocytes via PepT1 transporters, official textbook curricula state the end product of protein digestion entering the blood is free amino acids.
- Option C:** Polypeptides are intermediate digestive products, not the absorbable end products.
- Option D:** Ammonia is a toxic deamination byproduct formed in the liver during amino acid catabolism, not a digestive end product.

Question #69 Key: (C)CHEMISTRY
12. Transition Elements

Which of the following transition metals show a 3d5 configuration in their +2 oxidation state?

CORE CONCEPT & DERIVATION

First-row transition metals lose their valence 4s electrons prior to 3d electrons during ionization.

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

- Manganese has an atomic number of $Z = 25$ with ground-state electron configuration $[\text{Ar}] 4s^2 3d^5$.
- Forming the +2 oxidation state involves the loss of both 4s valence electrons:



- This leaves a stable, half-filled 3d subshell containing 5 unpaired electrons.

Why other options are incorrect:

- Option A:** $\text{Cu}^{2+} (Z = 29)$ loses one 4s and one 3d electron, leaving $[\text{Ar}] 3d^9$.
- Option B:** $\text{Fe}^{2+} (Z = 26)$ loses two 4s electrons, leaving $[\text{Ar}] 3d^6$.
- Option D:** $\text{Zn}^{2+} (Z = 30)$ loses two 4s electrons, leaving a completely filled $[\text{Ar}] 3d^{10}$ subshell.

Question #70 Key: (A)

CHEMISTRY
17. Aldehydes & Ketones

Which of the following reagents can be used to distinguish between 1-pentyne and 2-pentyne?

CORE CONCEPT & DERIVATION

Terminal alkynes possess an acidic, sp-hybridized terminal hydrogen that reacts with heavy metal complexes to yield insoluble metal acetylide precipitates.

Formula / Rule / Reaction:



Solution:

- 1-Pentyne is a terminal alkyne possessing a weakly acidic acetylenic proton ($\equiv \text{C}-\text{H}$).
- When treated with Tollens' reagent (ammoniacal silver nitrate, $\text{AgNO}_3 + \text{NH}_4\text{OH}$), 1-pentyne produces a distinct white precipitate of silver pentynide.
- 2-Pentyne is an internal alkyne ($\text{CH}_3-\text{C} \equiv \text{C}-\text{CH}_2\text{CH}_3$) lacking an acidic terminal hydrogen, showing no reaction.

Why other options are incorrect:

- Option B:** Alkaline KMnO_4 (Baeyer's reagent) oxidizes both terminal and internal alkynes, decoloring the purple solution in both cases.
- Option C:** Bromine in carbon tetrachloride (Br_2/CCl_4) undergoes halogen addition with both alkynes, discharging the reddish-brown color in both.
- Option D:** Acidified potassium dichromate does not serve as a diagnostic qualitative test to distinguish between alkyne isomers.

Question #71 Key: (B)

CHEMISTRY
16. Alcohols & PhenolsIn $\text{S}_{\text{N}}1$ reactions, the correct order of reactivity of alkyl halide is?

CORE CONCEPT & DERIVATION

 $\text{S}_{\text{N}}1$ substitution proceeds via a two-step mechanism with a rate-determining unimolecular step that forms a carbocation intermediate.

Formula / Rule / Reaction:



Solution:

- The rate-limiting step of an $\text{S}_{\text{N}}1$ reaction is the heterolytic cleavage of the carbon-halogen bond to form a planar carbocation intermediate.
- Tertiary carbocations are heavily stabilized by electron-donating inductive effects (+I) and hyperconjugation from three alkyl groups, lowering the activation energy for tertiary alkyl halides.
- Therefore, the reactivity order is tertiary > secondary > primary.

Why other options are incorrect:

- Option A:** Primary > secondary > tertiary represents the order of reactivity for $\text{S}_{\text{N}}2$ mechanisms governed by steric hindrance.
- Option C:** Secondary alkyl halides are intermediate in reactivity and do not exceed tertiary halides in $\text{S}_{\text{N}}1$ pathways.
- Option D:** Primary alkyl halides are the least reactive substrates in $\text{S}_{\text{N}}1$ reactions due to the instability of primary carbocations.

Question #72 Key: (B)

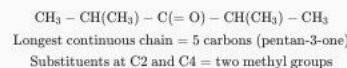
CHEMISTRY
17. Aldehydes & Ketones

What is the IUPAC name of diisopropyl ketone?

CORE CONCEPT & DERIVATION

IUPAC rules dictate selecting the longest continuous carbon chain containing the principal carbonyl group, numbered from the end yielding the lowest locant for the carbonyl carbon.

Formula / Rule / Reaction:



Solution:

- Diisopropyl ketone consists of two isopropyl groups, $-\text{CH}(\text{CH}_3)_2$, attached to a central carbonyl group: $(\text{CH}_3)_2\text{CH}-\text{CO}-\text{CH}(\text{CH}_3)_2$.
- The longest continuous hydrocarbon chain consists of 5 carbon atoms, with the carbonyl group at carbon-3 (pentan-3-one).
- Methyl groups are present at positions 2 and 4, producing the systematic name 2,4-dimethylpentan-3-one.

Why other options are incorrect:

- Option A:** Fails to select the longest continuous carbon chain and treats the isopropyl groups as branch chains on a 3-carbon parent.
- Option C:** Places the carbonyl group at carbon-2, which is structurally impossible for symmetrical diisopropyl ketone.
- Option D:** Corresponds to pentan-3-one without accounting for the branched methyl carbons.

Question #73 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones

The appearance of a silver mirror in Tollens test indicates the presence of which of the follow...

CORE CONCEPT & DERIVATION

Aldehydes possess a readily oxidizable carbonyl hydrogen atom, allowing them to reduce mild oxidizing metal complexes.

Formula / Rule / Reaction:



Solution:

- Tollens' reagent contains the diamminesilver(I) coordination cation, $[\text{Ag}(\text{NH}_3)_2]^+$.
- Aldehydes are readily oxidized to carboxylate anions while reducing Ag^+ ions to elemental silver (Ag^0), which coats the inner glass surface of the test tube as a reflective silver mirror.

Why other options are incorrect:

- Option A:** Ketones lack a hydrogen atom bonded directly to the carbonyl carbon and cannot be oxidized by Tollens' reagent under normal conditions.
- Option C:** Carboxylic acids are already at a high oxidation state and do not reduce Tollens' reagent (with the single exception of formic acid).
- Option D:** Monohydric aliphatic alcohols are not oxidized by mild ammoniacal silver solutions.

Question #74 Key: (D)

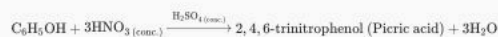
CHEMISTRY
16. Alcohols & Phenols

If phenol is treated with 3 moles of conc. HNO_3 in the presence of H_2SO_4 , what will be the prod...

CORE CONCEPT & DERIVATION

The hydroxyl group ($-\text{OH}$) on phenol is a strong activating group that strongly directs electrophilic substitution to both ortho and para positions.

Formula / Rule / Reaction:



Solution:

- Because the lone pairs on the phenolic oxygen resonate into the aromatic ring, the ortho and para positions become activated toward electrophilic attack.
- When treated with excess concentrated nitric acid and concentrated sulfuric acid, nitration occurs simultaneously at positions 2, 4, and 6.
- The resulting product is 2,4,6-trinitrophenol, commonly known as picric acid.

Why other options are incorrect:

- Option A:** o-Nitrophenol is formed when phenol reacts with dilute nitric acid at low temperatures (room temperature).
- Option B:** p-Nitrophenol is also a product of dilute nitric acid nitration, separated from the ortho isomer by steam distillation.
- Option C:** A mixture of mono-nitrophenols is produced exclusively using dilute HNO_3 at low temperature, not conc. HNO_3 .

Question #75 Key: (C)

CHEMISTRY
02. Atomic Structure

When the 6d orbital is filled, the entering electron goes into?

CORE CONCEPT & DERIVATION

The Aufbau principle dictates that subshells fill in order of increasing $(n + l)$ values, filling the subshell with the lower principal quantum number n when sums are identical.

Formula / Rule / Reaction:

$$\begin{aligned} \text{For } 6d: n = 6, l = 2 &\implies n + l = 8 \\ \text{For } 7p: n = 7, l = 1 &\implies n + l = 8 \quad (n = 7 > 6) \\ \text{Filling sequence: } 5f &\rightarrow 6d \rightarrow 7p \rightarrow 8s \end{aligned}$$

Solution:

- Calculate $n + l$ values for subsequent available subshells: for 6d, $n + l = 6 + 2 = 8$.
- The subshell with the next lowest energy is 7p, where $n + l = 7 + 1 = 8$. Because $n = 7$ is greater than $n = 6$, 7p fills immediately after 6d.

Why other options are incorrect:

- Option A:** For 7f, $n + l = 7 + 3 = 10$, which possesses significantly higher energy.
- Option B:** For 7d, $n + l = 7 + 2 = 9$, which fills after the 8s and 5g/6f levels.
- Option D:** The 7s subshell ($n + l = 7 + 0 = 7$) fills before the 5f and 6d orbitals.

Question #76 Key: (A)

CHEMISTRY
02. Atomic Structure

Which element has the ground state electronic configuration of $1s^2, 2s^2, 2p^6, 3s^2, 3p^6$?

CORE CONCEPT & DERIVATION

The ground-state electronic configuration reflects the total number of atomic electrons distributed among orbitals according to Hund's rule and Pauli's principle.

Formula / Rule / Reaction:

$$\text{Total electrons } (Z) = 2 + 2 + 6 + 2 + 6 = 18$$

Solution:

- Summing the superscripts gives the total number of electrons in the neutral atom:

$$2 + 2 + 6 + 2 + 6 = 18 \text{ electrons}$$

- An atomic number of $Z = 18$ corresponds to the noble gas argon (Ar), which possesses a complete stable valence octet ($3s^2 3p^6$).

Why other options are incorrect:

- Option B:** Chlorine has $Z = 17$ with configuration $1s^2 2s^2 2p^6 3s^2 3p^5$.
- Option C:** Sodium has $Z = 11$ with configuration $1s^2 2s^2 2p^6 3s^1$.
- Option D:** Sulfur has $Z = 16$ with configuration $1s^2 2s^2 2p^6 3s^2 3p^4$.

Question #77 Key: (D)

CHEMISTRY
12. Transition Elements

What is the proton (atomic number) of an element that has four unpaired electrons in its ground...

CORE CONCEPT & DERIVATION

Hund's rule states that degenerate orbitals must each be occupied by one electron with parallel spins before pairing begins.

Formula / Rule / Reaction:



Solution:

- Consider iron ($Z = 26$): its ground state electronic configuration is $[\text{Ar}]4s^2 3d^6$.
- The five degenerate 3d orbitals hold 6 electrons. Distributing these according to Hund's rule: one orbital receives a paired set of 2 electrons, while the remaining four orbitals each hold a single unpaired electron.
- This results in exactly 4 unpaired electrons.

Why other options are incorrect:

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

Question #78 Key: (A)

CHEMISTRY
04. Gases

Which one of the following gases has the lowest density under room conditions?

CORE CONCEPT & DERIVATION

From the ideal gas law, the density of a gas at constant temperature and pressure is directly proportional to its molar mass.

Formula / Rule / Reaction:

$$d = \frac{PM}{RT} \Rightarrow d \propto M \quad (\text{at constant } P \text{ and } T)$$

Solution:

- Compare the molar masses of the gases in their natural molecular states under room conditions:

$$\begin{aligned} M(\text{Ne}) &= 20.18 \text{ g/mol} \\ M(\text{N}_2) &= 28.02 \text{ g/mol} \\ M(\text{O}_2) &= 32.00 \text{ g/mol} \\ M(\text{F}_2) &= 38.00 \text{ g/mol} \end{aligned}$$

- Because neon has the lowest molar mass, it has the lowest gas density.

Why other options are incorrect:

- Option B:** Nitrogen exists as diatomic N_2 ($M = 28 \text{ g/mol}$), which is denser than neon.
- Option C:** Diatomic oxygen ($M = 32 \text{ g/mol}$) has a density of approximately 1.31 g/L .
- Option D:** Diatomic fluorine ($M = 38 \text{ g/mol}$) has the highest density among the listed gases.

Question #79 Key: (A)

CHEMISTRY
04. Gases

The process of heat flow between hotter and colder gases remains continued until all the molecu...

CORE CONCEPT & DERIVATION

Absolute temperature is a direct macroscopic measure of the average translational kinetic energy of gas molecules.

Formula / Rule / Reaction:

$$E_k = \frac{1}{2} m \overline{v^2} = \frac{3}{2} k_B T$$

Solution:

- Thermal equilibrium between two bodies occurs when net heat exchange ceases, meaning both systems reach the exact same temperature ($T_1 = T_2$).
- According to the kinetic molecular theory of gases, temperature is defined solely by the mean translational kinetic energy of the molecules.
- Therefore, heat transfers until the average translational kinetic energy of all gas molecules becomes equal.

Why other options are incorrect:

- Option B:** Rotational kinetic energy depends on molecular geometry and moments of inertia, varying widely across different gas species at thermal equilibrium.
- Option C:** Ideal gas molecules exert no intermolecular forces, making their translational potential energy zero.
- Option D:** Vibrational modes are quantum-mechanically frozen for many gases at room temperature and do not define thermal equilibrium.

Question #80 Key: (D)

CHEMISTRY
07. Equilibrium

What is the ultimate fate of a reversible reaction?

CORE CONCEPT & DERIVATION

Reversible reactions in a closed system advance toward a state of dynamic chemical equilibrium.

Formula / Rule / Reaction:

$$R_{\text{forward}} = R_{\text{reverse}} \Rightarrow \frac{d[\text{Reactants}]}{dt} = \frac{d[\text{Products}]}{dt} = 0$$

Solution:

- In a reversible reaction, products recombine to regenerate the original reactants.
- As the forward rate decreases and the reverse rate increases, they eventually become equal, reaching dynamic equilibrium.
- At this point, macroscopic concentrations of reactants and products remain constant, resulting in no net change in concentration over time.

Why other options are incorrect:

- Option A:** Reversible reactions do not go to completion (100% conversion) in a closed system.
- Option B:** Reactants are never completely consumed because the reverse reaction regenerates them.
- Option C:** Products are continuously regenerated and maintained at constant equilibrium levels.

Question #81 Key: (B)

CHEMISTRY
07. Equilibrium

In a reversible reaction, when a product is removed, the equilibrium shifts towards the:

CORE CONCEPT & DERIVATION

Le Chatelier's principle states that if a dynamic equilibrium is disturbed, the system will adjust to counteract the imposed change.

Formula / Rule / Reaction:

$$Q_c = \frac{[\text{Products}]}{[\text{Reactants}]} < K_c \Rightarrow \text{Forward shift toward products}$$

Solution:

- Removing a product decreases its concentration in the reaction mixture, causing the reaction quotient Q_c to drop below the equilibrium constant K_c .
- To restore equilibrium, the forward reaction accelerates relative to the reverse reaction, consuming reactants to produce more product.
- Thus, the position of equilibrium shifts toward the product side (to the right).

Why other options are incorrect:

- Option A:** The equilibrium shifts toward the reactants only if products are added or reactants are removed.
- Option C:** Chemical equilibria shift in one specific thermodynamic direction, not alternating back and forth.
- Option D:** Changing product concentration changes Q_c , which alters the equilibrium state.

Question #82 Key: (B)

CHEMISTRY
08. Reaction Kinetics

The rate of reaction between two specific time intervals is called?

CORE CONCEPT & DERIVATION

Reaction rates can be expressed over finite macroscopic intervals (average rate) or at a specific single point in time (instantaneous rate).

Formula / Rule / Reaction:

$$\text{Average Rate} = -\frac{\Delta[\text{Reactant}]}{\Delta t} = +\frac{\Delta[\text{Product}]}{\Delta t}$$

Solution:

- The change in concentration of a reactant or product divided by a finite measurable time interval ($\Delta t = t_2 - t_1$) is defined as the average rate of reaction.
- In contrast, the rate at a single instant as $\Delta t \rightarrow 0$ represents the instantaneous rate:

$$\text{Instantaneous Rate} = \lim_{\Delta t \rightarrow 0} \frac{\Delta[C]}{\Delta t} = \frac{d[C]}{dt}$$

Why other options are incorrect:

- Option A:** The instantaneous rate is evaluated at a single point in time using the tangent slope, not across a finite interval.
- Option C:** Rate of reaction is a general category that must be specified as average or instantaneous.
- Option D:** Minimum rate describes the lowest speed during a reaction profile, not an interval-based rate.

Question #83 Key: (C)

CHEMISTRY
08. Reaction Kinetics

How will be the rate of reaction if the slope of the curve is greater near the start of the reaction?

CORE CONCEPT & DERIVATION

On a concentration-time graph, the derivative $d[C]/dt$ represents the instantaneous reaction rate, directly proportional to the steepness of the tangent slope.

Formula / Rule / Reaction:

$$\text{Rate} = \left| \frac{d[C]}{dt} \right| = \text{Slope of tangent}$$

Solution:

- At the start of a chemical reaction, reactant concentrations are at their maximum.
- A steeper, greater slope on a concentration versus time curve indicates a higher rate of concentration change per unit time.
- Therefore, a greater initial slope corresponds to a greater initial rate of reaction.

Why other options are incorrect:

- Option A:** A constant rate is characterized by a straight line with a fixed slope (zero-order reaction), not a steep curve.
- Option B:** At dynamic equilibrium, the net slope of the concentration curve becomes horizontal (slope = 0).
- Option D:** A smaller or flatter slope indicates a slower, lesser reaction rate.

Question #84 Key: (C)

CHEMISTRY
09. Thermochemistry

What is the reason for energy changes in chemical reactions?

CORE CONCEPT & DERIVATION

The enthalpy change (ΔH) of a chemical reaction equals the difference between the energy absorbed to break reactant bonds and the energy released to form product bonds.

Formula / Rule / Reaction:

$$\Delta H_{\text{rxn}} = \sum \text{Bond Energy (bonds broken)} - \sum \text{Bond Energy (bonds formed)}$$

Solution:

- Breaking existing chemical bonds in reactant molecules is an endothermic process that requires energy input.
- Forming new chemical bonds in product molecules is an exergonic process that releases energy.
- The net energy change (exothermic or endothermic) reflects the quantitative balance between bond breakage and bond formation.

Why other options are incorrect:

- Option A:** Bond formation only accounts for the energy-releasing step of a reaction.
- Option B:** Bond breakage only accounts for the energy-absorbing step of a reaction.
- Option D:** Ionic bonding is a single type of chemical interaction and does not explain universal thermodynamic reaction changes.

Question #85 Key: (A)

CHEMISTRY
09. Thermochemistry

What is the unit of heat capacity?

CORE CONCEPT & DERIVATION

Heat capacity (C) is the amount of heat energy required to raise the temperature of a given body by one kelvin.

Formula / Rule / Reaction:

$$C = \frac{q}{\Delta T} \Rightarrow \text{Units} = \frac{\text{Joules (J)}}{\text{Kelvin (K)}} = \text{J} \cdot \text{K}^{-1}$$

Solution:

- Heat absorbed (q) is measured in Joules (J).
- Temperature change (ΔT) is measured in Kelvin (K).
- Dividing heat by temperature change gives $\text{J} \cdot \text{K}^{-1}$ (or J/K).

Why other options are incorrect:

- Option B:** $\text{kJ} \cdot \text{mol}^{-1}$ is the unit of molar enthalpy (such as molar heat of vaporization or molar heat of combustion).
- Option C:** " kJ/K " is a dimensionally invalid unit.
- Option D:** " $\text{kJ} \cdot \text{mol}$ " is not an established physical unit in thermodynamics.

Question #86 Key: (B)

CHEMISTRY
14. Hydrocarbons

The addition reaction of 2-butene with HBr produces?

CORE CONCEPT & DERIVATION

Electrophilic addition of hydrogen halides to symmetrical alkenes yields a single monohaloalkane product.

Formula / Rule / Reaction:



Solution:

- 2-Butene is a symmetrical alkene. Addition of an electrophilic proton (H^+) to either sp^2 carbon generates an equivalent secondary carbocation ($\text{CH}_3 - \text{CH}_2 - \text{C}^+ \text{H} - \text{CH}_3$).
- The bromide nucleophile (Br^-) attacks this carbocation, forming 2-bromobutane as the sole product.

Why other options are incorrect:

- Option A:** 1-Bromobutane requires addition across terminal 1-butene via anti-Markovnikov free-radical addition.
- Option C:** 2,3-Dibromobutane requires halogenation with molecular bromine (Br_2), not hydrohalogenation with HBr.
- Option D:** 1,3-Dibromobutane cannot form from addition to 2-butene.

Question #87 Key: (D)

CHEMISTRY
14. Hydrocarbons

Under suitable conditions alkanes cannot undergo _____ reactions?

CORE CONCEPT & DERIVATION

Alkanes are saturated aliphatic hydrocarbons possessing exclusively single σ bonds, which prevents them from undergoing addition reactions without eliminating atoms.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Carbon atoms in alkanes are sp^3 -hybridized, with all four valence orbitals fully saturated by single covalent bonds.
- Because they lack π -bonds, alkanes cannot accept additional atoms without cleaving existing bonds via free-radical substitution.
- Thus, alkanes cannot undergo addition reactions.

Why other options are incorrect:

- Option A:** Alkanes readily undergo free-radical substitution reactions (such as photochemical chlorination).
- Option B:** Alkanes undergo exothermic combustion in the presence of excess oxygen to yield CO_2 and H_2O .
- Option C:** Alkanes are already fully hydrogenated saturated compounds; they cannot be hydrogenated further.

Question #88 Key: (B)

CHEMISTRY
01. Stoichiometry

A compound of phosphorus oxide has 43.6% of oxygen. Its empirical formula is?

CORE CONCEPT & DERIVATION

The empirical formula represents the simplest whole-number ratio of atoms of each element in a chemical compound.

Formula / Rule / Reaction:

$$\text{Moles of element} = \frac{\text{Mass (g)}}{\text{Molar mass (g/mol)}}$$

Solution:

- In a 100 g sample: Mass of O = 43.6 g and Mass of P = $100 - 43.6 = 56.4$ g.
- Calculate molar amounts:

$$n_{\text{P}} = \frac{56.4 \text{ g}}{31.0 \text{ g/mol}} = 1.819 \text{ mol}$$

$$n_{\text{O}} = \frac{43.6 \text{ g}}{16.0 \text{ g/mol}} = 2.725 \text{ mol}$$

- Determine the mole ratio by dividing by the smaller value (1.819):

$$\text{P} : \text{O} = \frac{1.819}{1.819} : \frac{2.725}{1.819} = 1.00 : 1.50$$

- Multiply by 2 to obtain whole numbers: P_2O_3 .

Why other options are incorrect:

- Option A:** P_2O_5 corresponds to:

$$\% \text{O} = \frac{5 \times 16}{(2 \times 31) + (5 \times 16)} = \frac{80}{142} = 56.3\% \text{ oxygen}$$

- Option C:** P_2O_2 contains a large excess of phosphorus, giving less than 18% oxygen.
- Option D:** PO_2 requires an oxygen-to-phosphorus ratio of 2:1 (50.8% oxygen).

Question #89 Key: (B)

CHEMISTRY
01. Stoichiometry

Which element is used as a standard to determine the atomic mass of an element?

CORE CONCEPT & DERIVATION

The international standard for relative atomic masses is defined against the pure carbon-12 (^{12}C) isotope.

Formula / Rule / Reaction:

$$1 \text{ amu} = 1 \text{ u} = \frac{1}{12} \times \text{Mass of one atom of } ^{12}\text{C} \approx 1.66054 \times 10^{-27} \text{ kg}$$

Solution:

- By international agreement (IUPAC, 1961), the carbon-12 isotope is assigned an exact mass of 12.000 atomic mass units.
- The atomic masses of all other elements are measured relative to this single baseline reference.

Why other options are incorrect:

- Option A:** Hydrogen-1 was used as the historical standard in the early 19th century, but was later replaced due to isotopic variability.
- Option C:** Phosphorus has never been employed as an international mass scale reference.
- Option D:** Chlorine consists of two abundant stable isotopes (^{35}Cl and ^{37}Cl), making it unsuitable as an absolute reference.

Question #90 Key: (A)

CHEMISTRY
01. Stoichiometry

The average weight of atoms of an element compared to the weight of one atom of ^{12}C is ca...

CORE CONCEPT & DERIVATION

Atomic weight (relative atomic mass) is a dimensionless physical quantity defined as the ratio of the average mass of atoms of an element to $1/12$ the mass of an atom of carbon-12.

Formula / Rule / Reaction:

$$A_r = \frac{\text{Average mass of one atom of element}}{\frac{1}{12} \times \text{Mass of one atom of } ^{12}\text{C}}$$

Solution:

- By definition, relative atomic mass compares the average isotopic mass of an element against the standard mass of one carbon atom (specifically $1/12$ of a ^{12}C atom).
- Carbon provides a solid, readily handled, stable baseline with negligible chemical handling loss.

Why other options are incorrect:

- Option B:** Helium is an inert noble gas that has never served as the international standard for relative atomic masses.
- Option C:** Hydrogen was replaced by oxygen in the early 20th century, which was subsequently replaced by carbon-12.
- Option D:** Nitrogen is not used as the standard element for defining atomic weights.

Question #91 Key: (D)

CHEMISTRY
01. Stoichiometry

The same moles of H_2 , N_2 , and O_2 are present in 0.1 cc volume at STP. Which one has the greatest...

CORE CONCEPT & DERIVATION

Avogadro's hypothesis states that equal numbers of moles of any gas contain an identical number of molecules regardless of chemical identity.

Formula / Rule / Reaction:

$$N = n \times N_A \quad (N_A = 6.022 \times 10^{23} \text{ molecules/mol})$$

Solution:

- The question states that the same number of moles (n) of H_2 , N_2 , and O_2 are present.
- Because total particle number is governed solely by $N = n \times N_A$, identical molar quantities contain the exact same number of molecules.

Why other options are incorrect:

- Option A:** N_2 does not contain more molecules because molecular count is independent of molar mass.
- Option B:** H_2 occupies the same molar count, despite having a lower molecular mass and smaller size.
- Option C:** O_2 has the same number of molecules as the other gases.

Question #92 Key: (D)

CHEMISTRY
05. Liquids

Which is not a property of liquid?

CORE CONCEPT & DERIVATION

Properties of liquids describe physical characteristics intrinsic to the liquid state, whereas phase transitions describe boundaries between physical states.

Formula / Rule / Reaction:



Solution:

- Osmotic pressure, freezing point, vapor pressure, surface tension, viscosity, and diffusion are defined physical properties of the liquid state and liquid solutions.
- Melting is a phase transition that solid substances undergo when heated to their melting point; liquids do not melt.

Why other options are incorrect:

- Option A:** Osmotic pressure is a colligative property of liquid solutions.
- Option B:** Freezing point is a physical characteristic property of liquids as they transition into solids.
- Option C:** Diffusion is a transport property of liquids driven by random molecular motion.

Question #93 Key: (C)

CHEMISTRY
05. Liquids

Which type of forces exist between iodine molecules?

CORE CONCEPT & DERIVATION

Nonpolar homonuclear diatomic molecules interact via transient electrostatic attractions known as London dispersion forces.

Formula / Rule / Reaction:

$$\text{London dispersion force} = \text{Instantaneous temporary dipole} \cdots \text{Induced dipole}$$

Solution:

- Iodine (I_2) is a nonpolar homonuclear diatomic molecule with zero permanent dipole moment.
- Because iodine has a large, polarizable electron cloud (53 electrons per atom), temporary fluctuations in electron density create instantaneous dipoles.
- These induce complementary dipoles in adjacent molecules, generating instantaneous dipole-induced dipole attractions (London dispersion forces).

Why other options are incorrect:

- Option A:** Dipole-dipole forces require molecules with permanent dipole moments (polar molecules such as HCl).
- Option B:** Dipole-induced dipole forces (Debye forces) occur between a permanent polar molecule and a nonpolar molecule.
- Option D:** "Non-polar forces" is an informal phrase; the formal chemical term is instantaneous dipole-induced dipole forces.

Question #94 Key: (C)

CHEMISTRY
06. Solids

In anisotropic crystals, which property does not change with the change in direction of crystal...

CORE CONCEPT & DERIVATION

Anisotropy is the directional dependence of physical properties in a crystalline solid, resulting from non-uniform lattice spacing along different axes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Anisotropic properties include electrical conductance, thermal conductivity, cleavage planes, and refractive index, all of which vary depending on the crystallographic axis of measurement.
- Molar mass is an intrinsic scalar chemical property determined solely by chemical formula and isotopic composition; it remains completely independent of physical direction or geometry.

Why other options are incorrect:

- Option A:** Electrical conductance in anisotropic crystals (such as graphite along vs. across graphene sheets) varies significantly with direction.
- Option B:** Thermal conductance varies according to directional lattice vibration (phonon) pathways.
- Option D:** Refractive index varies with direction in non-cubic crystals, leading to optical phenomena like double refraction (birefringence).

Question #95 Key: (B)

CHEMISTRY
06. Solids

In metals, why does electric conductivity decrease with the increase of temperature?

CORE CONCEPT & DERIVATION

Electrical resistance in metallic conductors arises from collisions between conduction electrons and vibrating lattice cations.

Formula / Rule / Reaction:

$$R_T = R_0(1 + \alpha \Delta T) \Rightarrow \text{Lattice vibration amplitude } A \propto T$$

Solution:

- In a metallic lattice, delocalized valence electrons move freely through an array of positive metal ions.
- As temperature rises, metal cations absorb thermal energy and vibrate with greater amplitude about their fixed equilibrium lattice sites.
- These larger lattice oscillations increase the scattering cross-section and collision frequency with drifting conduction electrons, increasing electrical resistance and decreasing electrical conductivity.

Why other options are incorrect:

- Option A:** The thermal root-mean-square speed of electrons increases with temperature, rather than decreasing.
- Option C:** Electrons constantly change direction due to collisions, which is a symptom of scattering rather than the root cause of decreased conductivity.
- Option D:** Thermal conduction via electron collisions explains thermal transport, not the decrease in electrical conductivity.

Question #96 Key: (B)

CHEMISTRY
03. Chemical Bonding

Why does fluorine have less electron affinity as compared to bromine?

CORE CONCEPT & DERIVATION

Electron affinity anomalies in small period-2 non-metals arise from high electron-electron repulsion within compact valence subshells.

Formula / Rule / Reaction:

$$\text{Electron Affinity values: Cl } (-349 \text{ kJ/mol}) > \text{Br } (-325 \text{ kJ/mol}) > \text{F } (-328 \text{ kJ/mol})$$

Solution:

- Fluorine has an exceptionally small atomic radius with its nine electrons compressed into compact 2s and 2p orbitals.
- This produces a dense electron cloud with high inter-electronic repulsion, which partially destabilizes and opposes the entry of an incoming electron.
- In larger halogens, the valence subshells are more diffuse, resulting in lower electron-electron repulsion and an anomalously favorable electron affinity compared to compact fluorine.

Why other options are incorrect:

- Option A:** Fluorine has the highest electronegativity (4.0 on the Pauling scale), which would favor, rather than reduce, electron attraction.
- Option C:** All halogens (F, Cl, Br, I) possess seven valence electrons; this factor does not explain differences among them.
- Option D:** High ionization energy measures the energy required to remove an electron, not the affinity for adding one.

Question #97 Key: (C)

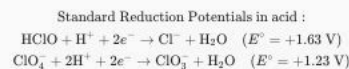
CHEMISTRY
10. Electrochemistry

Which oxyacid of halogen is a strong oxidizing agent?

CORE CONCEPT & DERIVATION

The oxidizing power of chlorine oxoacids decreases as the oxidation state of the central halogen increases, due to kinetic stability and oxo-anion resonance stabilization.

Formula / Rule / Reaction:



Solution:

- Hypochlorous acid (HClO, where Cl is in the +1 oxidation state) has the highest reduction potential and is the most powerful oxidizing agent among the chlorine oxoacids.
- As oxygen atoms are added (from HClO to HClO₄), the conjugate base undergoes resonance stabilization across multiple electronegative oxygen atoms, making perchloric acid (HClO₄) thermodynamically and kinetically more stable and a weaker oxidizing agent in dilute solution.

Why other options are incorrect:

- Option A:** HClO₄ is the strongest acid due to extensive conjugate base resonance, but it is the weakest oxidizing agent in dilute aqueous conditions.
- Option B:** HClO₃ is intermediate in oxidizing ability, weaker than HClO.
- Option D:** HClO₂ has a lower reduction potential than HClO.

Question #98 Key: (C)

CHEMISTRY
14. Hydrocarbons

Alkylbenzene is formed when benzene is treated with an alkyl halide in the presence of anhydrous...

CORE CONCEPT & DERIVATION

Electrophilic aromatic substitution of an alkyl group onto a benzene ring using an alkyl halide and a Lewis acid catalyst is termed Friedel-Crafts alkylation.

Formula / Rule / Reaction:



Solution:

- The Lewis acid catalyst (anhydrous $AlCl_3$) coordinates to the alkyl halide ($R-X$), generating an electrophilic carbocation or polarized complex ($R^+ \cdot AlCl_3X^-$).
- The nucleophilic aromatic π -system attacks this carbocation, followed by deprotonation to regenerate aromaticity and form an alkylbenzene.

Why other options are incorrect:

- Option A:** Halogenation replaces an aromatic hydrogen with a halogen atom using molecular halogen ($Cl_2/FeCl_3$).
- Option B:** Friedel-Crafts acylation introduces an acyl group ($R-CO-$) using an acyl halide ($RCOCl$).
- Option D:** Sulphonation introduces a sulfonic acid group ($-SO_3H$) using fuming sulfuric acid.

Question #99 Key: (C)

CHEMISTRY
16. Alcohols & PhenolsThe increasing stability order of the following compounds (1) $CH_3CH_2CH_2^+$ (2) $(CH_3)_3C^+$ (3) $CH_3...$

CORE CONCEPT & DERIVATION

Carbocation stability is governed by the dispersal of positive charge through hyperconjugation and inductive electron donation from adjacent alkyl groups.

Formula / Rule / Reaction:



Solution:

- Compound (2) is the tertiary carbocation, $(CH_3)_3C^+$, stabilized by 9 hyperconjugative α -hydrogens and three electron-donating methyl groups.
- Compound (3) is the secondary carbocation, $CH_3CH_2CH^+CH_3$, stabilized by 5 hyperconjugative α -hydrogens.
- Compound (1) is the primary carbocation, $CH_3CH_2CH_2^+$, with only 2 α -hydrogens.
- Arranged from most to least stable gives: $2 > 3 > 1$.

Why other options are incorrect:

- Option A:** Inverts the true stability sequence by ranking primary above tertiary.
- Option B:** Places the secondary carbocation ahead of the more stable tertiary carbocation.
- Option D:** Incorrectly orders secondary and tertiary carbocations relative to primary.

Question #100 Key: (B)

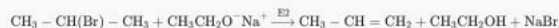
CHEMISTRY
16. Alcohols & Phenols

When 2-bromopropane reacts with sodium ethoxide, the major product is/are?

CORE CONCEPT & DERIVATION

Secondary alkyl halides reacting with strong, unhindered alkoxide bases predominantly undergo bimolecular elimination (E_2) rather than substitution.

Formula / Rule / Reaction:



Solution:

- 2-Bromopropane is a secondary alkyl halide. Sodium ethoxide ($NaOCH_2CH_3$) is a strong nucleophile and strong Brønsted base.
- Because steric hindrance around the secondary carbon impedes direct S_N2 backside attack, the ethoxide ion abstracts a β -proton, causing concerted E_2 elimination of bromide.
- This produces propene as the predominant major product.

Why other options are incorrect:

- Option A:** Propane is a fully saturated alkane and cannot be formed without strong catalytic reduction.
- Option C:** Ethyl isopropyl ether is the minor product formed via S_N2 substitution.
- Option D:** Propane is not formed, making this option incorrect.

Question #101 Key: (C)

CHEMISTRY
17. Aldehydes & Ketones

Propanone can be prepared from propyne by:

CORE CONCEPT & DERIVATION

Hydration of alkynes in the presence of mercuric sulfate and sulfuric acid follows Markovnikov's rule to produce an unstable enol intermediate that rapidly tautomerizes into a ketone.

Formula / Rule / Reaction:



Solution:

- Propyne undergoes electrophilic addition of water catalyzed by Hg^{2+} and dilute H_2SO_4 at approximately $60^\circ C$ to $80^\circ C$.
- Following Markovnikov addition, the hydroxyl group attaches to the internal carbon atom, forming prop-1-en-2-ol (an enol).
- The enol rapidly tautomerizes to its thermodynamically stable keto form, propanone (acetone).

Why other options are incorrect:

- Option A:** Passing alkyne and steam over magnesium at elevated temperatures does not yield selective hydration to ketones.
- Option B:** Zinc chromate catalysts are used in industrial methanol synthesis, not for the alkyne hydration pathway.
- Option D:** Iodine and sodium hydroxide form the iodoform reagent, which cleaves methyl ketones rather than synthesizing propanone from propyne.

Question #102 Key: (A)

CHEMISTRY
18. Carboxylic Acids

If carboxylic acid and ketone groups C=O are present in a chain, then final name will be given ...

CORE CONCEPT & DERIVATION

IUPAC priority rules mandate that the carboxylic acid group takes precedence over ketones, designating the acid as the principal functional group suffix while the ketone is cited as a prefix.

Formula / Rule / Reaction:

IUPAC Priority : $-\text{COOH} > -\text{CHO} > \text{C}=\text{O} > -\text{OH} > -\text{NH}_2 > \text{C}=\text{C} > \text{C}\equiv\text{C}$

Solution:

- When both a carboxylic acid ($-\text{COOH}$) and a ketone ($\text{C}=\text{O}$) are present, the carboxylic acid receives the highest priority and determines the terminal suffix "-oic acid".
- The ketone carbonyl oxygen is treated as a substituent and designated by the prefix "oxo-" along with its numerical locant.
- Therefore, the structure is named as an oxo-alkanoic acid (prefix: oxo, suffix: oic acid).

Why other options are incorrect:

- Option B:** "-one" is a suffix used only when the ketone is the principal functional group of the molecule.
- Option C:** Dual suffixes cannot be used simultaneously for different oxygenated functional groups under standard IUPAC rules.
- Option D:** Option A is the precise nomenclature protocol.

Question #103 Key: (B)

CHEMISTRY
18. Carboxylic Acids

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

CORE CONCEPT & DERIVATION

Acid strength is quantified by the equilibrium degree of dissociation (α) and the acid dissociation constant (K_a) in aqueous solution.

Formula / Rule / Reaction:



Solution:

- Sulfuric acid is a mineral acid that undergoes complete ionization in dilute aqueous solution, releasing a high concentration of hydronium ions.
- Acetic acid is an organic weak acid that ionizes only slightly (typically less than 1% to 2% at standard concentrations), existing primarily as undissociated molecules.
- Its lesser degree of ionization accounts directly for its lower acid strength.

Why other options are incorrect:

- Option A:** Thermal decomposition is a pyrolytic property that does not govern standard solution acid-base dissociation equilibria.
- Option C:** The presence of the carboxyl group defines carboxylic acids, but structural group classification does not explain the physical degree of ionization.
- Option D:** The methyl group exhibits an electron-donating inductive effect (+I), which destabilizes the conjugate base, but the fundamental definition of weak acid behavior is incomplete ionization.

Question #104 Key: (A)

CHEMISTRY
18. Carboxylic Acids

Mr. Khan mixes acetic acid with thionyl chloride. Which product is obtained?

CORE CONCEPT & DERIVATION

Thionyl chloride selectively replaces the carboxylic hydroxyl group with a chlorine atom, producing an acyl chloride alongside gaseous byproducts.

Formula / Rule / Reaction:



Solution:

- Nucleophilic attack of the carboxylic oxygen on thionyl chloride forms a chlorosulfite intermediate.
- Subsequent attack by chloride ion displaces the leaving group, producing acetyl chloride (CH_3COCl).
- Both sulfur dioxide (SO_2) and hydrogen chloride (HCl) evolve as gases, driving the reaction to completion.

Why other options are incorrect:

- Option B:** Chloromethane (CH_3Cl) is not formed because the carbon-carbon single bond is not cleaved under these conditions.
- Option C:** Ester formation (methyl acetate) requires an alcohol reacting with the acid, not thionyl chloride.
- Option D:** Decarboxylation to chloromethane does not occur during this nucleophilic acyl substitution.

Question #105 Key: (B)

CHEMISTRY
16. Alcohols & Phenols

Dehydration of alcohol gives which of the following products in the presence of H_2SO_4 at 1400?

CORE CONCEPT & DERIVATION

Acid-catalyzed dehydration of primary alcohols is temperature-dependent, yielding ethers via bimolecular condensation at lower temperatures and alkenes via elimination at higher temperatures.

Formula / Rule / Reaction:



Solution:

- At 140°C in the presence of excess ethanol and concentrated sulfuric acid, an unprotonated alcohol molecule performs an $\text{S}_\text{N}2$ attack on a protonated alkyloxonium ion.
- Loss of a proton from the resulting dialkyloxonium intermediate generates diethyl ether. (Note: "1400" in the question stem represents a typographical artifact for 140°C).

Why other options are incorrect:

- Option A:** Acetaldehyde requires oxidative dehydrogenation with potassium dichromate, not sulfuric acid dehydration.
- Option C:** Acetone is a three-carbon ketone that cannot be synthesized by dehydrating ethanol.
- Option D:** Ethyl chloride requires a halogenating reagent like HCl , PCl_5 , or SOCl_2 .

Question #106 Key: (C)

CHEMISTRY
18. Carboxylic Acids

Complete oxidation of alcohol gives which of the following?

CORE CONCEPT & DERIVATION

Primary alcohols undergo stepwise oxidation through an aldehyde intermediate, culminating in the formation of a carboxylic acid when treated with strong oxidizing agents.

Formula / Rule / Reaction:



Solution:

- Primary alcohols are first oxidized to aldehydes by the loss of two hydrogen atoms.
- Because aldehydes retain a reactive carbonyl hydrogen, strong aqueous oxidizing agents (such as acidified $\text{K}_2\text{Cr}_2\text{O}_7$ or KMnO_4) further oxidize them to carboxylic acids.
- Therefore, terminal complete oxidation yields a carboxylic acid.

Why other options are incorrect:

- Option A:** Aldehydes are partial or controlled oxidation products isolated only when using mild, anhydrous oxidants like PCC.
- Option B:** Alkanes are fully reduced hydrocarbons and cannot form via oxidation.
- Option D:** Ketones are the oxidation products of secondary alcohols and resist further oxidation without carbon chain fragmentation.

Question #107 Key: (A)

CHEMISTRY
07. Equilibrium

One can estimate the direction in which the equilibrium will shift with the help of:

CORE CONCEPT & DERIVATION

Le Chatelier's principle predicts the qualitative response of a chemical system at dynamic equilibrium to external changes in temperature, pressure, or concentration.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Le Chatelier's principle states that if a stress (change in concentration, temperature, or pressure) is applied to a system at equilibrium, the position of equilibrium will shift in the direction that counteracts the imposed stress.
- This provides a reliable predictive framework for determining whether the forward or reverse pathway is favored.

Why other options are incorrect:

- Option B:** The Law of Mass Action defines the mathematical relationship between reactant and product concentrations at equilibrium (the equilibrium constant expression), but does not predict stress-induced directional shifts.
- Option C:** Hess's Law states that total enthalpy change is independent of pathway, applicable to thermochemical state functions.
- Option D:** The law of heat of formation quantifies enthalpy changes accompanying compound formation from standard constituent elements.

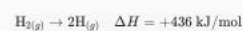
Question #108 Key: (C)

CHEMISTRY
03. Chemical BondingThe bond energy of hydrogen in the H_2 molecule is:

CORE CONCEPT & DERIVATION

Bond dissociation energy is the standard enthalpy change required to homolytically cleave one mole of gaseous covalent bonds into separate gaseous atoms.

Formula / Rule / Reaction:



Solution:

- The single sigma covalent bond between two $1s$ orbitals in an H_2 molecule has a characteristic bond length of 74 pm.
- Homolytic cleavage of this strong covalent bond requires an energy input of exactly 436 kJ/mol (or approximately 104 kcal/mol).

Why other options are incorrect:

- Option A:** 242 kJ/mol is the approximate bond dissociation energy of the chlorine molecule ($\text{Cl} - \text{Cl}$).
- Option B:** 431 kJ/mol represents the bond energy of a heteronuclear hydrogen halide bond, specifically $\text{H} - \text{Cl}$.
- Option D:** 346 kJ/mol corresponds to the standard carbon-carbon single bond energy ($\text{C} - \text{C}$).

Question #109 Key: (D)

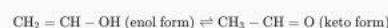
CHEMISTRY
13. Fundamental Principles of Organic Chemistry

What are vinyl alcohol and acetaldehyde?

CORE CONCEPT & DERIVATION

Tautomerism is a dynamic constitutional isomerism involving the rapid intramolecular migration of a proton accompanied by a switch between adjacent single and double bonds.

Formula / Rule / Reaction:



Solution:

- Vinyl alcohol (ethenol) and acetaldehyde (ethanal) share the identical molecular formula $\text{C}_2\text{H}_4\text{O}$.
- They interconvert via 1,3-proton migration between oxygen and carbon, accompanied by the shift of a π -electron pair.
- This represents keto-enol tautomerism, in which the keto form (acetaldehyde) is heavily favored thermodynamically.

Why other options are incorrect:

- Option A:** Position isomers possess identical functional groups located at different carbon positions along the same skeleton.
- Option B:** Functional group isomers differ in functional group but do not exist in rapid dynamic equilibrium under ambient conditions.
- Option C:** Metamers possess unequal distribution of alkyl carbon chains on either side of a polyvalent bridging heteroatom.

Question #110 Key: (A)

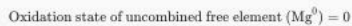
CHEMISTRY
10. Electrochemistry

What is the oxidation number of free magnesium?

CORE CONCEPT & DERIVATION

According to standard IUPAC oxidation state rules, any chemical element existing in its pure, uncombined, elemental state has an oxidation number of zero.

Formula / Rule / Reaction:



Solution:

- In elemental free magnesium metal, the atoms are not bonded to any other element and have neither lost nor gained electrons.
- Therefore, its formal oxidation number is identically 0.
- Magnesium displays an oxidation state of +2 only when chemically combined in compounds (such as MgCl_2 or MgO).

Why other options are incorrect:

- **Option B:** +1 is an unstable, non-standard oxidation state for alkaline earth metals.
- **Option C:** +2 is the oxidation number of magnesium in its combined ionic or covalent compounds, not in its free elemental state.
- **Option D:** +3 would require removing a core electron from a closed neon shell, which is chemically inaccessible.

Question #111 Key: (A)

CHEMISTRY
11. S & P Block Elements

Select the metal that is extracted from bauxite.

CORE CONCEPT & DERIVATION

Bauxite is the principal naturally occurring sedimentary mineral ore used in the industrial extraction of aluminum.

Formula / Rule / Reaction:



Solution:

- Bauxite consists primarily of hydrated aluminum oxides (gibbsite, boehmite, diaspore) mixed with iron oxide and silica impurities.
- It is purified via the Bayer process to yield pure anhydrous alumina (Al_2O_3), which is then dissolved in molten cryolite and electrolytically reduced to metallic aluminum via the Hall-Héroult process.

Why other options are incorrect:

- **Option B:** Calcium is commercially extracted from limestone (calcite, CaCO_3) or gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$).
- **Option C:** Magnesium is extracted from dolomite, magnesite, or seawater carnallite.
- **Option D:** Copper is extracted from sulfide ores such as chalcopyrite (CuFeS_2) or malachite.

Question #112 Key: (B)

CHEMISTRY
11. S & P Block Elements

Which of the following has the highest atomic radius in its period?

CORE CONCEPT & DERIVATION

Atomic radius decreases across any period from left to right due to the progressive increase in effective nuclear charge (Z_{eff}) with constant core shielding.

Formula / Rule / Reaction:

Atomic Radius across period : Group 1 (Alkali) > Group 2 > ... > Group 16 (Chalcogens) > Group 17 (Halogens)

Solution:

- As one moves from left to right across a horizontal period, protons are added to the nucleus while electrons enter the same principal valence shell.
- The steady rise in effective nuclear charge draws the electron cloud closer to the nucleus.
- Because alkali metals occupy Group 1 at the extreme left of each period, they possess the lowest effective nuclear charge and the largest atomic radius in their respective periods.

Why other options are incorrect:

- **Option A:** Alkaline earth metals (Group 2) have an additional nuclear proton, contracting their valence shell relative to Group 1.
- **Option C:** Chalcogens (Group 16) reside near the far right of the period and possess much smaller atomic radii.
- **Option D:** Halogens (Group 17) possess nearly the smallest covalent radii in any given period due to high effective nuclear charge.

Question #113 Key: (C)

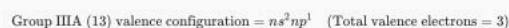
CHEMISTRY
11. S & P Block Elements

The electronic configurations of some elements are given below. Recognize the element that below...

CORE CONCEPT & DERIVATION

The main-group number in the classical Mendeleev/representative system (Group IIIA or Group 13) equals the total number of valence electrons in the outermost *s* and *p* subshells.

Formula / Rule / Reaction:



Solution:

- An element with the configuration $1s^2 2s^2 2p^1$ has 3 valence electrons in its second shell (two in 2s, one in 2p).
- This corresponds to boron ($Z = 5$), the head element of Group IIIA (Group 13).

Why other options are incorrect:

- **Option A:** $1s^2 2s^2 2p^3$ has 5 valence electrons, placing it in Group VA (Group 15, nitrogen family).
- **Option B:** $1s^2 2s^2 2p^4$ has 6 valence electrons, placing it in Group VIA (Group 16, chalcogens).
- **Option D:** $1s^2 2s^2 2p^2$ has 4 valence electrons, placing it in Group IVA (Group 14, carbon family).

Question #114 Key: (B)

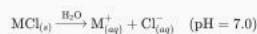
CHEMISTRY
11. S & P Block Elements

All alkali metals react with chlorine gas to form white metal chloride salt. The metal chloride...

CORE CONCEPT & DERIVATION

Salts formed by the neutralization of a strong alkali metal base with a strong acid do not undergo hydrolysis in water, producing a neutral aqueous solution.

Formula / Rule / Reaction:



Solution:

- Alkali metal chlorides (such as NaCl and KCl) are ionic crystalline solids with high lattice hydration energies that dissolve completely in water.
- Because neither Na^+ nor Cl^- hydrolyzes water (originating from the strong base NaOH and strong acid HCl), the concentrations of $[\text{H}^+]$ and $[\text{OH}^-]$ remain equal, yielding a neutral solution of pH 7.

Why other options are incorrect:

- Option A:** All alkali metal halides are highly soluble in water due to favorable ion-dipole hydration interactions.
- Option C:** Acidic solutions (pH 1) are formed by salts of weak bases and strong acids (such as AlCl_3), which undergo cationic hydrolysis.
- Option D:** Alkaline solutions (pH 14) are formed by basic salts (such as Na_2CO_3), not neutral binary halides.

Question #115 Key: (B)

CHEMISTRY
11. S & P Block Elements

Which one of them is amphoteric in nature?

CORE CONCEPT & DERIVATION

Amphoteric oxides are capable of reacting chemically as both an acid and a base, neutralizing both to form salts.

Formula / Rule / Reaction:



Solution:

- Beryllium has a small ionic radius and an exceptionally high charge density (q/r), giving its bonds significant covalent character via Fajans' rules.
- Consequently, beryllium oxide (BeO) reacts with strong acids to form beryllium salts and with strong bases to form beryllate complexes, demonstrating amphoteric character.

Why other options are incorrect:

- Option A:** Lithium oxide (Li_2O) is strongly basic, dissolving in water to form lithium hydroxide.
- Option C:** Calcium oxide (CaO) is an alkaline earth basic oxide that forms calcium hydroxide.
- Option D:** Potassium oxide (K_2O) is a strongly basic alkali oxide.

Question #116 Key: (A)

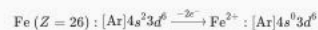
CHEMISTRY
12. Transition Elements

Which of the following is correct electronic configuration of iron (II) ion (atomic no. of Fe is...

CORE CONCEPT & DERIVATION

During the ionization of transition metals, the outermost 4s electrons are at a higher radial distribution and are removed before any 3d electrons.

Formula / Rule / Reaction:



Solution:

- Neutral iron has 26 electrons with ground state $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^6$.
- Forming the iron(II) cation (Fe^{2+}) involves the loss of two valence electrons, which are removed from the 4s subshell.
- This leaves six electrons in the 3d subshell: $[\text{Ar}]4s^03d^6$.

Why other options are incorrect:

- Option B:** $[\text{Ar}]4s^23d^6$ is the ground-state configuration of neutral, un-ionized elemental iron.
- Option C:** $[\text{Ar}]4s^23d^4$ incorrectly removes two 3d electrons while retaining the 4s electrons.
- Option D:** $[\text{Ar}]4s^23d^5$ represents a monovalent iron ion or unground state configuration.

Question #117 Key: (C)

CHEMISTRY
18. Carboxylic Acids

Which of the functional groups are present in ethyl acetate?

CORE CONCEPT & DERIVATION

Esters are carboxylic acid derivatives characterized by a carbonyl group bonded directly to an alkoxyl group.

Formula / Rule / Reaction:



Solution:

- Ethyl acetate (ethyl ethanoate) is formed by the condensation esterification of acetic acid with ethanol.
- Its structure contains the characteristic ester linkage ($-\text{COO}-$), consisting of a carbonyl group ($\text{C} = \text{O}$) linked to an ethoxy group ($-\text{OCH}_2\text{CH}_3$).

Why other options are incorrect:

- Option A:** The aldehyde group contains a terminal $-\text{CHO}$ unit.
- Option B:** The carboxyl group contains a free ionizable $-\text{COOH}$ unit, which is modified into an ester linkage here.
- Option D:** An ether group consists of an oxygen atom linked between two sp^3 carbons ($\text{R} - \text{O} - \text{R}$) without an adjacent carbonyl.

Question #118 Key: (B)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

What is the molecular formula of the pyridine molecule?

CORE CONCEPT & DERIVATION

Pyridine is a six-membered heterocyclic aromatic compound isoelectronic with benzene, in which one CH group is replaced by a nitrogen atom.

Formula / Rule / Reaction:



Solution:

- Pyridine consists of a planar hexagonal ring containing five carbon atoms and one nitrogen atom.
- Each carbon atom is bonded to a single hydrogen atom, yielding five carbons, five hydrogens, and one nitrogen atom: $\text{C}_5\text{H}_5\text{N}$.

Why other options are incorrect:

- Option A:** $\text{C}_6\text{H}_5\text{N}$ contains 6 carbon atoms, which violates the valency of the six-membered pyridine ring.
- Option C:** $\text{C}_5\text{H}_5\text{NH}$ represents the protonated pyridinium cation ($[\text{C}_5\text{H}_5\text{NH}]^+$).
- Option D:** $\text{C}_6\text{H}_6\text{N}$ is an invalid molecular formula.

Question #119 Key: (C)

CHEMISTRY
14. Hydrocarbons

Identify which method is used to prepare alkynes?

CORE CONCEPT & DERIVATION

Alkynes can be synthesized through the stepwise elimination of two equivalents of hydrogen halide from vicinal dihalides using a strong base, or through the electrolysis of aqueous salts of unsaturated dicarboxylic acids.

Formula / Rule / Reaction:



Solution:

- When a vicinal dihalide (such as 1,2-dibromoethane) is heated with a strong base like alcoholic potassium hydroxide (KOH) or sodium amide (NaNH_2), it undergoes double dehydrohalogenation to yield an alkyne (ethyne).
- Note on Board Key:** Option C in provincial past paper keys describes this dehydrohalogenation route. Additionally, Kolbe's electrolysis of potassium salts of unsaturated dicarboxylic acids (maleic or fumaric acid) also yields alkynes. Option C represents the standard laboratory elimination route taught in the textbook chapter on alkynes.

Why other options are incorrect:

- Option A:** Dehalogenation of vicinal dihalides with zinc metal in methanol yields an alkene, not an alkyne.
- Option B:** Dehydration of alcohols over alumina (Al_2O_3) at elevated temperatures yields alkenes.
- Option D:** Kolbe's electrolysis yields alkynes only when using unsaturated dicarboxylic acid salts (such as maleic acid), but standard saturated dicarboxylic acid salts yield alkenes.

Question #120 Key: (A)

CHEMISTRY
12. Transition Elements

Which of the following electronic configurations is correct for 24Cr?

CORE CONCEPT & DERIVATION

Subshells that are exactly half-filled or fully filled possess enhanced stability due to exchange energy and symmetric charge distribution.

Formula / Rule / Reaction:



Solution:

- Chromium has an atomic number of $Z = 24$.
- Transferring one electron from the 4s orbital to the 3d orbital creates a spherically symmetrical, half-filled 3d⁵ subshell and a half-filled 4s¹ subshell.
- This configuration maximizes the quantum mechanical exchange energy, making $1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 4s^1$ the true ground state.

Why other options are incorrect:

- Option B:** $[\text{Ar}]4s^13d^4$ accounts for only 23 electrons.
- Option C:** $[\text{Ar}]3d^6$ lacks the 4s electron and represents an unground state or excited ion.
- Option D:** The 4f subshell is empty in first-row transition elements and begins filling only at cerium ($Z = 58$).

Question #121 Key: (C)

CHEMISTRY
09. Current Electricity

The following formula can be used to determine the resistance of a length of conductor: [Formul...

CORE CONCEPT & DERIVATION

Electrical resistance depends directly on conductor length and inversely on cross-sectional area, scaled by an intrinsic material-specific constant called resistivity.

Formula / Rule / Reaction:

$$R = \frac{\rho l}{A} \implies \rho = \frac{RA}{l} \quad (\text{Units: } \Omega \cdot \text{m})$$

Solution:

- In the expression $R = \rho l / A$ (where "p" in the OCR scan represents the Greek letter ρ), R is electrical resistance, l is conductor length, and A is cross-sectional area.
- The proportionality constant ρ denotes the electrical resistivity (specific resistance) of the material, measured in ohm-meters ($\Omega \cdot \text{m}$).

Why other options are incorrect:

- Option A:** Cross-sectional area is represented by the variable A in square meters.
- Option B:** Conductor length is represented by l in meters.
- Option D:** Resistance per unit length is defined by the ratio R/l , not ρ .

Question #122 Key: (A)

CHEMISTRY
09. Current Electricity

The resistance of the wire varies inversely as:

CORE CONCEPT & DERIVATION

Resistance is inversely proportional to the cross-sectional area of a uniform conductor because a broader cross-section provides more parallel pathways for drifting electrons.

Formula / Rule / Reaction:

$$R = \rho \frac{l}{A} \implies R \propto \frac{1}{A}$$

Solution:

- From the resistance formula, doubling the cross-sectional area (A) halves the resistance (R) for a wire of constant length and material.
- Therefore, the electrical resistance of the wire varies inversely with its cross-sectional area.

Why other options are incorrect:

- Option B:** Resistance varies directly with length ($R \propto l$).
- Option C:** Resistance varies directly with the resistivity of the material ($R \propto \rho$).
- Option D:** For metallic conductors, resistance increases directly with rising temperature.

Question #123 Key: (D)

PHYSICS
08. Electrostatics

A capacitor of capacitance C has charge Q and stored energy is W . If the charge is increased to ...

CORE CONCEPT & DERIVATION

The electrostatic potential energy stored in an electric field within a capacitor is directly proportional to the square of its accumulated charge.

Formula / Rule / Reaction:

$$W = \frac{Q^2}{2C}$$

Solution:

- The initial stored energy is given by $W = \frac{Q^2}{2C}$.
- If the charge is increased to $Q' = 2Q$ while capacitance C remains constant:

$$W' = \frac{(2Q)^2}{2C} = \frac{4Q^2}{2C} = 4\left(\frac{Q^2}{2C}\right) = 4W$$

- Thus, doubling the stored charge quadruples the electrostatic potential energy.

Why other options are incorrect:

- Option A:** $W/4$ would result if the charge were halved to $Q/2$.
- Option B:** $W/2$ incorrectly assumes energy depends inversely on charge.
- Option C:** $2W$ incorrectly assumes a linear relationship between stored energy and charge.

Question #124 Key: (B)

PHYSICS
08. Electrostatics

To store the electric charge the ultra-capacitors use _____ effect.

CORE CONCEPT & DERIVATION

Ultracapacitors (supercapacitors) store electrostatic charge via non-Faradaic electrical double-layer capacitance formed at an electrode-electrolyte interface.

Formula / Rule / Reaction:

$$C = \frac{\epsilon A}{d} \quad (\text{where } d \approx 1 \text{ nm at the Helmholtz double layer})$$

Solution:

- Ultracapacitors consist of porous high-surface-area carbon electrodes immersed in an electrolyte.
- When polarized, electrolyte ions migrate to the oppositely charged electrode surfaces, creating an electric double layer (the Helmholtz layer) separated by a distance of less than a nanometer.
- This double-layer effect yields extremely high capacitance per unit volume.

Why other options are incorrect:

- Option A:** A single layer would not provide the requisite charge separation interface between electrode and electrolyte.
- Option C:** Triple-layer capacitance is not a recognized physical charge storage mechanism.
- Option D:** Quadruple-layer effects do not exist in electrochemistry.

Question #125 Key: (C)

PHYSICS
08. Electrostatics

What is the potential difference between two points in an electric field if it takes 600 J of e...

CORE CONCEPT & DERIVATION

Electric potential difference between two points is defined as the work done per unit positive test charge moved between those points against an electrostatic field.

Formula / Rule / Reaction:

$$\Delta V = \frac{W}{q}$$

Solution:

- Given work done $W = 600 \text{ J}$ and charge $q = 2 \text{ C}$.
- Calculate the potential difference:

$$\Delta V = \frac{600 \text{ J}}{2 \text{ C}} = 300 \text{ J/C} = 300 \text{ V}$$

Why other options are incorrect:

- Option A:** 1200 V is obtained by incorrectly multiplying work by charge ($W \times q = 600 \times 2$).
- Option B:** 800 V is an arithmetic error.
- Option D:** 0 V would imply zero work was required to move the charge through the electric field.

Question #126 Key: (B)PHYSICS
08. Electrostatics

A charged particle moves in a uniform electric field between two oppositely charged parallel me...

CORE CONCEPT & DERIVATION

The electrostatic force exerted by an electric field on a charged particle is determined entirely by field strength and charge magnitude, independent of particle velocity.

Formula / Rule / Reaction:

$$F_e = qE = q\left(\frac{V}{d}\right)$$

Solution:

- The electric field between parallel plates with potential difference V and separation d is uniform: $E = V/d$.
- The resulting electrostatic force is $F_e = q(V/d)$, requiring knowledge of the charge q , potential difference V , and plate separation d .
- Unlike magnetic Lorentz forces ($F_B = qvB \sin \theta$), the electrostatic force is independent of particle speed.

Why other options are incorrect:

- Option A:** Particle charge q is required as force is directly proportional to it.
- Option C:** Plate separation d is required to calculate the electric field intensity from voltage.
- Option D:** Potential difference V is required to determine the field strength.

Question #127 Key: (D)PHYSICS
08. Electrostatics

Gauss law cannot be used to find which of the following quantity?

CORE CONCEPT & DERIVATION

Gauss's law relates enclosed net charge to the total electric flux passing through a closed Gaussian surface, assuming the permittivity of the medium is an already known constitutive parameter.

Formula / Rule / Reaction:

$$\Phi_e = \oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enclosed}}}{\epsilon_0}$$

Solution:

- Gauss's law calculates electric field intensity (E) for highly symmetric charge distributions, electric flux density ($D = \epsilon E$), or total enclosed charge ($Q_{\text{enc}} = \epsilon_0 \Phi_e$).
- Permittivity (ϵ_0) is a fundamental universal physical constant of free space, not a dynamic electrostatic field variable determined using Gauss's law.

Why other options are incorrect:

- Option A:** Electric field intensity is calculated using Gauss's law across spherical, cylindrical, and planar symmetries.
- Option B:** Electric flux density (displacement field D) is determined directly by $\oint \vec{D} \cdot d\vec{A} = Q_{\text{free}}$.
- Option C:** Total enclosed charge is evaluated by calculating the surface integral of flux.

Question #128 Key: (B)PHYSICS
08. Electrostatics

Electric field intensity inside a hollow charged sphere is:

CORE CONCEPT & DERIVATION

In electrostatic equilibrium, excess charge on a conductor resides entirely on its outer surface, leaving the interior cavity completely field-free.

Formula / Rule / Reaction:

$$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{\text{enclosed}}}{\epsilon_0} = 0 \implies E_{\text{interior}} = 0$$

Solution:

- Construct a Gaussian spherical surface inside the hollow conductor with radius $r < R$.
- Because all charges reside on the external boundary, the enclosed charge Q_{enclosed} is zero.
- By Gauss's law, the electric flux and the net electric field intensity E throughout the interior cavity are identically zero (electrostatic shielding).

Why other options are incorrect:

- Option A:** Electric field intensity reaches its maximum on the outer surface of the sphere, not inside.
- Option C:** Negative electric field would require unneutralized negative charges trapped inside the cavity.
- Option D:** Positive electric field would require unneutralized positive charges located within the interior cavity.

Question #129 Key: (C)PHYSICS
08. Electrostatics

As per Coulomb's law, the force of attraction or repulsion between two-point charges is directl...

CORE CONCEPT & DERIVATION

Coulomb's law states that the electrostatic force between two stationary point charges is directly proportional to the product of their charges and inversely proportional to the square of their separation distance.

Formula / Rule / Reaction:

$$F = k \frac{|q_1 q_2|}{r^2}$$

Solution:

- From the mathematical expression of Coulomb's law, the force magnitude is directly proportional to the product of the magnitudes of the two charges ($F \propto |q_1 q_2|$).
- The force also obeys an inverse-square relationship with distance ($F \propto 1/r^2$).

Why other options are incorrect:

- Option A:** Electrostatic force depends on the product of the charges, not their algebraic or scalar sum.
- Option B:** The force is inversely proportional to the square of the distance, not directly proportional.
- Option D:** Dipole-dipole interactions follow higher inverse powers, but point-charge Coulombic force is not proportional to the cube of distance.

Question #130 Key: (A)PHYSICS
07. ThermodynamicsFor an ideal gas equation $PV = nRT$, the dimensions of Real Gas Constant R are:**CORE CONCEPT & DERIVATION**

Dimensional analysis evaluates physical constants by substituting base SI dimensions for primary physical quantities.

Formula / Rule / Reaction:

$$R = \frac{PV}{nT} \Rightarrow [R] = \frac{[P][V]}{[n][T]}$$

Solution:

- Dimensions of pressure (Force / Area):

$$[P] = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$$

- Dimensions of volume: $[V] = [L^3]$.

- Multiplying pressure by volume gives energy:

$$[PV] = [ML^{-1}T^{-2}][L^3] = [ML^2T^{-2}]$$

- Dividing by temperature ($[T] = [K]$) and treating molar amount as dimensionless (per mole basis):

$$[R] = [M^1L^2T^{-2}K^{-1}]$$

Why other options are incorrect:

- **Option B:** Incorporates incorrect length and time exponents.
- **Option C:** Corresponds to energy divided by length to the fourth power, missing the proper volume dimensions.
- **Option D:** Fails to account for the $[L^3]$ volume factor multiplying pressure.

Question #131 Key: (B)PHYSICS
05. WavesA distant star is receding from the Earth with a speed of 1.40×10^7 m/s. It emits light of fre...**CORE CONCEPT & DERIVATION**

When a light source recedes from an observer, the observed frequency shifts to lower values (redshift) governed by the relativistic Doppler formula.

Formula / Rule / Reaction:

$$f_{\text{obs}} = f_{\text{source}} \left(1 - \frac{v}{c}\right) \quad (\text{for } v \ll c)$$

Solution:

- Calculate the recession parameter:

$$\frac{v}{c} = \frac{1.40 \times 10^7 \text{ m/s}}{3.00 \times 10^8 \text{ m/s}} \approx 0.0467$$

- Apply the Doppler shift formula:

$$f_{\text{obs}} = (4.57 \times 10^{14} \text{ Hz})(1 - 0.0467) = (4.57 \times 10^{14})(0.9533) \approx 4.36 \times 10^{14} \text{ Hz}$$

Why other options are incorrect:

- **Option A:** 2.04×10^{13} Hz represents an order-of-magnitude calculation error.
- **Option C:** 4.57×10^{14} Hz is the unshifted emitted frequency of the stationary star.
- **Option D:** 4.79×10^{14} Hz corresponds to a blueshift, which occurs only if the star is approaching Earth.

Question #132 Key: (C)PHYSICS
05. Waves

The speed of sound in an ideal gas depends upon:

CORE CONCEPT & DERIVATION

Newton-Laplace theory states that sound propagation in a gas is an adiabatic process, with speed determined by temperature, density, and adiabatic index.

Formula / Rule / Reaction:

$$v = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{M}}$$

Solution:

- The velocity of sound in a gas depends inversely on the square root of gas density ($v \propto 1/\sqrt{\rho}$) and directly on the square root of absolute temperature ($v \propto \sqrt{T}$).

- Therefore, the physical speed of sound in a gas is governed by its temperature and density.

Why other options are incorrect:

- **Option A:** "Ice" is an irrelevant solid state that does not determine sound propagation in a gas.
- **Option B:** Acoustic wave speed is independent of frequency in non-dispersive media, and fog represents suspended water droplets.
- **Option D:** Sound speed is independent of wave amplitude for linear acoustic waves.

Question #133 Key: (D)PHYSICS
05. Waves

If transverse waves are passing through a medium, then particles of the medium:

CORE CONCEPT & DERIVATION

Mechanical wave propagation transfers energy and momentum through a medium while its constituent particles oscillate about fixed equilibrium positions.

Formula / Rule / Reaction:

$$y(t) = A \sin(\omega t - kx)$$

Solution:

- In a transverse mechanical wave, the disturbance propagates horizontally while the individual particles of the medium oscillate perpendicular to the direction of wave travel.

- The restoring forces of the medium cause these particles to undergo simple harmonic motion (SHM) about their mean equilibrium positions without undergoing net translational displacement.

Why other options are incorrect:

- **Option A:** Medium particles do not remain stationary; they continuously oscillate and pass energy to adjacent particles.
- **Option B:** Particles do not experience permanent bulk translation away with the wave.
- **Option C:** Particles oscillate symmetrically around equilibrium rather than moving unidirectionally toward the source.

Question #134 Key: (A)PHYSICS
05. Waves

When a wave goes from one medium to another, there is a no change in the:

CORE CONCEPT & DERIVATION

The boundary condition between two physical media requires continuous wave oscillation, making wave frequency an invariant property determined solely by the source.

Formula / Rule / Reaction:

$$v = f\lambda \implies f = \frac{v_1}{\lambda_1} = \frac{v_2}{\lambda_2} = \text{Constant}$$

Solution:

- When a wave refracts across an interface into a new medium, its propagation speed (v) changes due to differing inertial and elastic properties of the medium.
- To maintain wave crest continuity across the boundary, the wavelength (λ) changes proportionally with velocity.
- Because the oscillation frequency (f) is set by the driving source, it remains unchanged.

Why other options are incorrect:

- **Option B:** Amplitude changes because energy is partitioned into reflected and transmitted components at the boundary.
- **Option C:** Wavelength changes in direct proportion to velocity: $\lambda_2 = \lambda_1(v_2/v_1)$.
- **Option D:** Velocity changes because the optical or acoustic impedance differs across media.

Question #135 Key: (D)PHYSICS
05. Waves

Wave trough refers to the:

CORE CONCEPT & DERIVATION

A periodic transverse waveform oscillates above and below its undisturbed baseline, defined by alternating crests and troughs.

Formula / Rule / Reaction:

$$\text{Trough} = \text{Position of maximum negative displacement } (y = -A)$$

Solution:

- A crest is the highest point of a transverse wave corresponding to maximum positive displacement ($+A$).
- A trough is the lowest point of the transverse wave corresponding to maximum negative displacement ($-A$) below the undisturbed equilibrium level.

Why other options are incorrect:

- **Option A:** Wavelength is the spatial distance between two consecutive in-phase points (such as crest-to-crest or trough-to-trough).
- **Option B:** Wave speed is the velocity at which the phase of the wave propagates through space.
- **Option C:** The highest point of the wave is termed the crest.

Question #136 Key: (D)PHYSICS
07. Thermodynamics

First law of thermodynamics concerns with the conservation of:

CORE CONCEPT & DERIVATION

The First Law of Thermodynamics is the application of the universal conservation of energy principle to thermodynamic systems.

Formula / Rule / Reaction:

$$\Delta U = Q - W \quad (\text{or } \Delta U = Q + W)$$

Solution:

- The First Law of Thermodynamics establishes that total energy in an isolated system remains constant; it can change form between heat, work, and internal energy, but cannot be created or destroyed.
- Therefore, it expresses the fundamental principle of the conservation of energy.

Why other options are incorrect:

- **Option A:** Heat alone is not conserved because it can be converted into mechanical work or internal energy.
- **Option B:** Work alone is not conserved because it can be converted into thermal energy through dissipative forces.
- **Option C:** Conservation of linear and angular momentum are independent mechanics principles distinct from thermodynamic energy conservation.

Question #137 Key: (C)PHYSICS
07. Thermodynamics

An ideal gas has molar specific heat C_p at constant pressure. When the temperature of n moles is...

CORE CONCEPT & DERIVATION

The internal energy of an ideal gas depends solely on its absolute temperature, with changes governed by the molar heat capacity at constant volume C_v .

Formula / Rule / Reaction:

$$\Delta U = nC_v\Delta T \quad \text{and} \quad C_p - C_v = R \implies C_v = C_p - R$$

Solution:

- For any process involving an ideal gas, the change in internal energy is given by:

$$\Delta U = nC_v\Delta T$$

- According to Mayer's relation, the molar heat capacity at constant volume is $C_v = C_p - R$.
- Substituting this into the internal energy equation:

$$\Delta U = n(C_p - R)\Delta T$$

Why other options are incorrect:

- **Option A:** $nC_p\Delta T$ represents the total heat transferred at constant pressure ($Q_p = \Delta H$), not internal energy change.
- **Option B:** $n(C_p + R)\Delta T$ uses an invalid specific heat relationship.
- **Option D:** $n(2C_p + R)\Delta T$ is dimensionally inconsistent with Mayer's relation.

Question #138 Key: (A)PHYSICS
13. Electronics

The ohmmeter of a portable digital multi meter need:

CORE CONCEPT & DERIVATION

Measuring electrical resistance requires an internal electromotive force to pass a known test current through the component under evaluation.

Formula / Rule / Reaction:

$$R_x = \frac{V_{\text{internal}}}{I_{\text{measured}}} - R_{\text{internal}}$$

Solution:

- An ohmmeter determines unknown resistance by applying a small known DC voltage across the test leads and measuring the resulting current.
- Because a passive resistor cannot generate its own electrical energy, the multimeter must contain an internal DC power source (such as a 9V or 1.5V internal battery) to drive the test circuit.

Why other options are incorrect:

- **Option B:** Wet cells are large, liquid-electrolyte industrial batteries (such as lead-acid batteries) unsuitable for portable digital multimeters.
- **Option C:** A voltmeter is an operational mode of the multimeter, not its internal driving power supply.
- **Option D:** An ammeter is a current-measuring function of the multimeter, not its internal power source.

Question #139 Key: (D)PHYSICS
09. Current Electricity

A wire of uniform area of cross-section A , length L , and resistance R is cut into two equal ...

CORE CONCEPT & DERIVATION

Resistivity is an intrinsic material property that depends on electronic band structure and temperature, remaining independent of conductor geometry.

Formula / Rule / Reaction:

$$\rho = \frac{m}{ne^2\tau} = \text{Constant (at constant temperature)}$$

Solution:

- While the electrical resistance of the wire halves ($R' = R/2$) when its length is halved, its resistivity (ρ) is an intensive property characteristic of the substance itself.
- Cutting the wire changes its physical dimensions, but does not alter the material identity or temperature, so the resistivity remains unchanged.

Why other options are incorrect:

- **Option A:** Doubling applies to conductivity or resistance under specific structural modifications, but resistivity is invariant to cutting.
- **Option B:** One-fourth would apply to the resistance of parts placed in parallel, not material resistivity.
- **Option C:** Resistance halves ($R/2$), but resistivity remains constant.

Question #140 Key: (B)PHYSICS
10. Electromagnetism

If 0.5 T field is applied over an area of 2-meter square which lies at an angle of 60 degree wi...

CORE CONCEPT & DERIVATION

Magnetic flux measures the total magnetic field passing through a given surface area, evaluated by the scalar dot product of field and area vectors.

Formula / Rule / Reaction:

$$\Phi_B = BA \cos \theta$$

Solution:

- Given magnetic field $B = 0.5 \text{ T}$ and surface area $A = 2 \text{ m}^2$.
- Using the orientation angle $\theta = 60^\circ$ from the examination convention:

$$\Phi_B = (0.5 \text{ T})(2 \text{ m}^2) \cos(60^\circ) = (1.0)(0.5) = 0.5 \text{ Wb}$$

- Thus, the resulting magnetic flux is 0.5 Weber (Wb).

Why other options are incorrect:

- **Option A:** Tesla (T) is the unit of magnetic flux density, not magnetic flux (Weber).
- **Option C:** 0.25 Wb is obtained if the cosine term is squared or evaluated incorrectly.
- **Option D:** Combines an incorrect numerical value with the wrong unit (Tesla).

Question #141 Key: (C)PHYSICS
10. Electromagnetism

The magnitude of magnetic force will be maximum on current carrying conductor in uniform magne...

CORE CONCEPT & DERIVATION

The magnetic force on a current-carrying conductor in a uniform field follows a vector cross-product relationship, reaching its maximum when the conductor is orthogonal to the field lines.

Formula / Rule / Reaction:

$$\vec{F} = I(\vec{L} \times \vec{B}) \implies F = ILB \sin \theta$$

Solution:

- The magnetic force depends directly on $\sin \theta$, where θ is the angle between the conductor length vector and the magnetic field vector.
- The sine function reaches its maximum value of 1 when $\theta = 90^\circ$:

$$F_{\text{max}} = ILB \sin(90^\circ) = ILB$$

- Therefore, the magnetic force is maximized when the conductor is oriented perpendicular to the magnetic field.

Why other options are incorrect:

- **Option A:** When parallel ($\theta = 0^\circ$), $\sin(0^\circ) = 0$, resulting in zero magnetic force.
- **Option B:** At 45° , $\sin(45^\circ) = 1/\sqrt{2} \approx 0.707$, yielding roughly 71% of maximum force.
- **Option D:** When antiparallel ($\theta = 180^\circ$), $\sin(180^\circ) = 0$, resulting in zero force.

Question #142 Key: (A)

PHYSICS
11. Electromagnetic Induction

In principle, the transformer consists of two coils of copper, electrically insulated from each...

CORE CONCEPT & DERIVATION

Transformers rely on mutual induction between two windings linked by a common ferromagnetic core with high magnetic permeability.

Formula / Rule / Reaction:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \quad (\text{assuming complete magnetic flux linkage via soft iron core})$$

Solution:

- A transformer consists of primary and secondary copper coils wound around a shared laminated soft iron core.
- The soft iron core provides high magnetic permeability, channeling the magnetic flux generated by the primary coil directly through the secondary coil with minimal flux leakage.

Why other options are incorrect:

- Option B:** A copper core is non-ferromagnetic (diamagnetic) and cannot efficiently concentrate magnetic flux.
- Option C:** Gold is diamagnetic, has low magnetic permeability, and is economically impractical.
- Option D:** Solid steel has high magnetic retentivity and broad hysteresis loops, which would lead to large energy losses compared to soft iron.

Question #143 Key: (C)

PHYSICS
14. Dawn of Modern Physics

In Compton effect, the incident photon when compared to the scattered photon is of:

CORE CONCEPT & DERIVATION

Compton scattering is an elastic collision in which an incident X-ray or gamma-ray photon transfers kinetic energy and momentum to a stationary electron, increasing the photon's wavelength.

Formula / Rule / Reaction:

$$\lambda' - \lambda = \frac{h}{m_0 c} (1 - \cos \theta) \Rightarrow \lambda' > \lambda$$

$$E = \frac{hc}{\lambda} \quad \text{and} \quad p = \frac{h}{\lambda}$$

Solution:

- During scattering, the photon loses energy to the recoil electron, so the scattered photon emerges with longer wavelength ($\lambda' > \lambda$).
- Because energy and momentum are inversely proportional to wavelength, the incident photon possesses higher frequency, greater energy, and greater momentum than the scattered photon.

Why other options are incorrect:

- Option A:** While true, it is incomplete because the incident photon also carries greater momentum.
- Option B:** While true, it omits the corresponding energy and momentum relationships.
- Option D:** Equal energy occurs only in unshifted coherent Thomson scattering, not inelastic Compton scattering.

Question #144 Key: (C)

PHYSICS
15. Atomic Spectra

Which of the following is the longest wavelength of radiation for the Paschen series?

CORE CONCEPT & DERIVATION

The Paschen spectral series consists of transitions terminating on the $n = 3$ energy level, with the longest wavelength corresponding to the smallest energy transition ($n = 4 \rightarrow n = 3$).

Formula / Rule / Reaction:

$$\frac{1}{\lambda_{\max}} = R_H \left(\frac{1}{3^2} - \frac{1}{4^2} \right) = 1.097 \times 10^7 \left(\frac{1}{9} - \frac{1}{16} \right) = 1.097 \times 10^7 \left(\frac{7}{144} \right)$$

Solution:

- Calculate the maximum wavelength:

$$\lambda_{\max} = \frac{144}{7 \times 1.097 \times 10^7} \approx 1.875 \times 10^{-6} \text{ m} = 0.000001875 \text{ m}$$

- This corresponds to 0.000001875 m (or 1.87 μm) in the infrared spectrum.

Why other options are incorrect:

- Option A:** 187000000 m is an erroneously scaled integer value from an uncorrected OCR string.
- Option B:** Has inverse meters as its unit, representing a wave number rather than a wavelength.
- Option D:** Uses inverse meter units rather than meters for wavelength.

Question #145 Key: (C)

PHYSICS
02. Force & Motion

Which of the following is the correct definition of variable velocity?

CORE CONCEPT & DERIVATION

Velocity is a vector quantity representing the time rate of change of displacement; it varies if either its magnitude (speed) or direction of motion changes.

Formula / Rule / Reaction:

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t} \neq \text{Constant}$$

Solution:

- Uniform velocity is defined as covering equal vector displacements in equal intervals of time.
- Conversely, variable velocity occurs when an object undergoes unequal displacements in equal successive intervals of time, reflecting changes in speed, direction, or both.

Why other options are incorrect:

- Option A:** Distance is a scalar quantity; covering unequal distances defines variable speed, not variable velocity.
- Option B:** Equal displacements made in unequal times is non-standard phrasing that describes changing average speed rather than defining variable instantaneous velocity.
- Option D:** Equal displacements in equal intervals of time is the standard definition of uniform (constant) velocity.

Question #146 Key: (D)

PHYSICS
09. Current Electricity

Which of the following is the fractional change in resistance per kelvin?

CORE CONCEPT & DERIVATION

The thermal sensitivity of an electrical component is quantified by the fractional change in its resistance per degree change in temperature.

Formula / Rule / Reaction:

$$\alpha = \frac{\Delta R}{R_0 \Delta T} \quad (\text{Units: } K^{-1} \text{ or } ^\circ C^{-1})$$

Solution:

- The fractional change in resistance is defined as the change in resistance (ΔR) divided by the original reference resistance (R_0).
- Dividing this dimensionless ratio by the temperature change in Kelvin (ΔT) gives $\alpha = \frac{\Delta R}{R_0 \Delta T}$, defined as the temperature coefficient of resistance.

Why other options are incorrect:

- Option A:** Conductivity is the reciprocal of resistivity ($\sigma = 1/\rho$), measuring ease of current flow.
- Option B:** Resistivity is the specific electrical resistance of a unit cube of a material.
- Option C:** The temperature coefficient of resistivity involves the fractional change in resistivity ($\frac{\Delta \rho}{\rho \Delta T}$), rather than macroscopic component resistance.

Question #147 Key: (A)

PHYSICS
09. Current Electricity

According to maximum power transfer theorem, which of the following is the max power delivered ...

CORE CONCEPT & DERIVATION

Maximum power is transferred from a real DC voltage source to an external load when the load resistance equals the internal resistance of the source.

Formula / Rule / Reaction:

$$P_{out} = I^2 R_L = \left(\frac{E}{R_L + r} \right)^2 R_L \implies P_{max} = \frac{E^2}{4r} \quad (\text{when } R_L = r)$$

Solution:

- Let a source have electromotive force E and internal resistance r , connected across a variable load resistance R_L .
- Circuit current is $I = \frac{E}{R_L + r}$, and power delivered to the load is $P = I^2 R_L = \frac{E^2 R_L}{(R_L + r)^2}$.
- Differentiating with respect to R_L and setting $dP/dR_L = 0$ yields the maximum condition $R_L = r$.
- Substituting $R_L = r$ into the power formula:

$$P_{max} = \frac{E^2(r)}{(r+r)^2} = \frac{E^2 r}{(2r)^2} = \frac{E^2 r}{4r^2} = \frac{E^2}{4r}$$

Why other options are incorrect:

- Option B:** $E^2/2r$ represents the total power produced by the source at maximum power transfer, half of which is dissipated internally.
- Option C:** $E^2/5r$ is an incorrect mathematical factor.
- Option D:** $E^2/3r$ does not satisfy the load-matching derivation.

Question #148 Key: (A)

PHYSICS
11. Electromagnetic Induction

Velocity selector will select only those charge particles whose velocity is given by:

CORE CONCEPT & DERIVATION

A velocity selector balances opposing electrostatic and magnetic forces to allow charged particles of a specific speed to pass undeflected.

Formula / Rule / Reaction:

$$\vec{F}_{net} = q(\vec{E} + \vec{v} \times \vec{B}) = 0 \implies qE = qvB$$

Solution:

- In crossed electric (E) and magnetic (B) fields, a charged particle experiences an electric force $F_e = qE$ and a magnetic force $F_B = qvB$.
- For the particle to travel in a straight line through the aperture without deflection, these forces must be equal in magnitude and opposite in direction:

$$qE = qvB \implies v = \frac{E}{B}$$

- Only particles with velocity $v = E/B$ pass undeflected.

Why other options are incorrect:

- Option B:** $v = B/E$ inverts the ratio and is dimensionally equivalent to inverse velocity.
- Option C:** $v = E \times B$ represents the Poynting vector direction, not particle speed.
- Option D:** At $v = 0$, magnetic force vanishes while the electric force deflects the particle into the plate.

Question #149 Key: (B)

PHYSICS
11. Electromagnetic Induction

The induced emf produced in the coil is sometimes called as?

CORE CONCEPT & DERIVATION

By Lenz's law, any induced electromotive force opposes the change in magnetic flux or driving current that creates it.

Formula / Rule / Reaction:

$$E_{back} = -L \frac{\Delta I}{\Delta t}$$

Solution:

- When current through a coil changes, self-induction generates an opposing electromotive force that resists the change in current.
- Because this induced voltage acts against the applied external voltage, it is commonly referred to as back emf (counter-electromotive force).

Why other options are incorrect:

- Option A:** Self-inductance (L) is the physical property and proportionality constant of the coil measured in Henries, not the induced voltage.
- Option C:** Motional emf is induced by mechanically moving a conductor through a magnetic field ($E = -vBL \sin \theta$).
- Option D:** Mutual inductance measures flux coupling between two distinct adjacent circuits.

Question #150 Key: (D)PHYSICS
11. Electromagnetic InductionThe quantity $\Delta\phi/\Delta t$ has the same units as that of?**CORE CONCEPT & DERIVATION**

Faraday's law of electromagnetic induction equates the time rate of change of magnetic flux to the magnitude of the induced electromotive force.

Formula / Rule / Reaction:

$$E = -N \frac{\Delta\Phi}{\Delta t} \Rightarrow \left[\frac{\Delta\Phi}{\Delta t} \right] = \frac{\text{Weber}}{\text{second}} = \text{Volt (V)}$$

Solution:

- Magnetic flux is measured in Webers ($\text{Wb} = \text{T} \cdot \text{m}^2 = \text{J/A}$).
- Dividing flux by time in seconds gives Webers per second:

$$\frac{\text{Wb}}{\text{s}} = \frac{\text{J}}{\text{A} \cdot \text{s}} = \frac{\text{J}}{\text{C}} = \text{Volt (V)}$$

- Because electromotive force (emf) is measured in volts, the quantity $\Delta\Phi/\Delta t$ shares identical physical units with emf.

Why other options are incorrect:

- **Option A:** Current is measured in Amperes (Coulombs per second).
- **Option B:** Magnetic induction is magnetic flux density, measured in Tesla (Wb/m^2).
- **Option C:** Electric charge is measured in Coulombs (Ampere-seconds).

Question #151 Key: (C)PHYSICS
09. Current Electricity

Voltage has the same units as that of?

CORE CONCEPT & DERIVATION

Electric potential difference (voltage) and electromotive force (emf) both quantify energy per unit electric charge.

Formula / Rule / Reaction:

$$V = \frac{W}{q} \quad \text{and} \quad E = \frac{W}{q} \Rightarrow \text{Units} = \frac{\text{Joule}}{\text{Coulomb}} = \text{Volt (V)}$$

Solution:

- Voltage represents the work done in moving a unit positive charge between two points in an electric circuit.
- Electromotive force (emf) represents the energy supplied by a non-electrical source per unit charge passing through it.
- Both quantities have the dimension of energy divided by charge, measured in the SI unit volt (V).

Why other options are incorrect:

- **Option A:** Current is the rate of charge flow, measured in amperes (Coulombs per second).
- **Option B:** Magnetic induction is magnetic flux density, measured in tesla ($\text{N} \cdot \text{A}^{-1} \cdot \text{m}^{-1}$).
- **Option D:** Mutual inductance measures flux linkage per unit current, measured in henries ($\text{V} \cdot \text{s} \cdot \text{A}^{-1}$).

Question #152 Key: (D)PHYSICS
11. Electromagnetic Induction

Working principle of magnetic levitation train is according to?

CORE CONCEPT & DERIVATION

Electrodynamic suspension in magnetic levitation systems relies on Lenz's law, where induced eddy currents create opposing magnetic fields that repel the vehicle upward.

Formula / Rule / Reaction:

$$E = -\frac{\Delta\Phi_B}{\Delta t} \Rightarrow \vec{F}_{\text{repulsive}} \propto -\frac{d\vec{B}}{dt}$$

Solution:

- As superconducting magnets on the train move rapidly past passive track coils, the changing magnetic flux induces circulating eddy currents.
- By Lenz's law, the magnetic field generated by these induced currents directly opposes the change in flux that created them.
- This creates a strong repulsive magnetic force between the train magnets and track coils, levitating the train above the guideway.

Why other options are incorrect:

- **Option A:** Faraday's law gives the quantitative magnitude of induced voltage, but Lenz's law dictates the directional repulsive stability that enables levitation.
- **Option B:** Planck's law governs blackbody spectral radiation and quantum photon energy.
- **Option C:** Ohm's law defines linear current-voltage relationships in resistive conductors.

Question #153 Key: (A)PHYSICS
11. Electromagnetic Induction

The expression for the emf produced by A. C. generator is?

CORE CONCEPT & DERIVATION

Rotating a conductive coil of wire in a uniform magnetic field produces an alternating electromotive force that varies sinusoidally with angular displacement.

Formula / Rule / Reaction:

$$\Phi_B(t) = BA \cos(\omega t) \Rightarrow E = -N \frac{d\Phi_B}{dt} = N\omega AB \sin(\omega t) = N\omega AB \sin \theta$$

Solution:

- Consider an armature coil with N turns and area A rotating with angular speed ω inside a uniform magnetic field B .
- The magnetic flux linked through the coil at any instant is $\Phi = BA \cos \theta$, where $\theta = \omega t$.
- Differentiating flux with respect to time according to Faraday's law yields the instantaneous induced emf: $E = N\omega AB \sin \theta$.

Why other options are incorrect:

- **Option B:** $N\omega AB \cos \theta$ describes the rate of change of an initially out-of-phase orientation where flux starts at zero.
- **Option C:** $N\omega AB$ represents the peak maximum emf (E_0), not the general instantaneous expression.
- **Option D:** $ILB \cos \theta$ relates to magnetic force or torque, not induced electromotive force.

Question #154 Key: (B)PHYSICS
13. Electronics

For the positive half cycle i.e., $0 \rightarrow T/2$, the diode D:

CORE CONCEPT & DERIVATION

A p-n junction diode conducts current when its anode is connected to a higher electric potential than its cathode (forward bias).

Formula / Rule / Reaction:

$$\text{Positive half-cycle: } V_{\text{anode}} > V_{\text{cathode}} \implies \text{Forward biased (Diode conducts)}$$

Solution:

- During the positive half-cycle of an input AC voltage (from $t = 0$ to $T/2$), the terminal connected to the p-type anode becomes positive relative to the n-type cathode.
- This reduces the depletion width and lowers the barrier potential across the junction.
- The diode becomes forward biased, offering very low dynamic resistance and conducting forward current through the load.

Why other options are incorrect:

- Option A:** Reverse bias occurs during the negative half-cycle ($T/2$ to T) when the anode is negative relative to the cathode.
- Option C:** A diode behaves as an open switch during reverse bias, not during the conducting forward half-cycle.
- Option D:** Maximum resistance characterizes reverse bias where only tiny minority leakage currents flow.

Question #155 Key: (B)PHYSICS
14. Dawn of Modern Physics

The process of ejection of loosely bound electrons from a certain photo sensitive surface by ab...

CORE CONCEPT & DERIVATION

The photoelectric effect is the instantaneous emission of electrons from a metallic or photosensitive surface upon absorption of electromagnetic radiation above a threshold frequency.

Formula / Rule / Reaction:

$$hf = \Phi + K_{\text{max}} = hf_0 + \frac{1}{2}mv_{\text{max}}^2$$

Solution:

- When incident photons of energy hf strike a photosensitive surface, each photon can transfer its entire energy to a single bound electron.
- If this energy exceeds the surface work function ($\Phi = hf_0$), the electron escapes from the surface as a photoelectron.
- This phenomenon is defined as the photoelectric effect.

Why other options are incorrect:

- Option A:** The Compton effect involves the inelastic scattering of high-energy X-ray or gamma photons by stationary electrons, with an increase in photon wavelength.
- Option C:** Pair production is the spontaneous conversion of a high-energy photon ($E \geq 1.02 \text{ MeV}$) into an electron-positron pair in the vicinity of a nucleus.
- Option D:** Blackbody radiation is thermal electromagnetic radiation emitted by an idealized non-reflecting body in thermodynamic equilibrium.

Question #156 Key: (A)PHYSICS
14. Dawn of Modern Physics

In Compton effect, a photon of a certain wavelength collides with a stationary electron. The wa...

CORE CONCEPT & DERIVATION

In an elastic Compton collision, the incident photon transfers a fraction of its energy and momentum to a recoil electron, lowering the scattered photon's energy.

Formula / Rule / Reaction:

$$\Delta\lambda = \lambda' - \lambda = \frac{h}{m_0c}(1 - \cos\theta) \implies \lambda' = \lambda + \Delta\lambda > \lambda$$

Solution:

- During scattering, the incident photon imparts kinetic energy to the target electron.
- Because total energy is conserved, the energy of the scattered photon is reduced: $E' < E$.
- Because photon energy is inversely proportional to wavelength ($E = hc/\lambda$), a lower energy corresponds to a longer scattered wavelength ($\lambda' > \lambda$).

Why other options are incorrect:

- Option B:** A shorter wavelength would require the scattered photon to gain energy, violating conservation of energy.
- Option C:** The wavelength remains unchanged only in classical coherent Thomson scattering, not inelastic Compton collisions.
- Option D:** An infinite wavelength would mean the photon surrendered all its energy, which is described by photoelectric absorption, not Compton scattering.

Question #157 Key: (C)PHYSICS
15. Atomic Spectra

The Balmer series of hydrogen is important because it:

CORE CONCEPT & DERIVATION

The Balmer series comprises electronic transitions from outer orbits down to the second principal energy level ($n = 2$) of atomic hydrogen.

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{2^2} - \frac{1}{n^2} \right) \quad (\text{where } n = 3, 4, 5, \dots; \lambda \in 380 - 750 \text{ nm})$$

Solution:

- The transition energies for the Balmer series fall between approximately 1.89 eV and 3.40 eV.
- These transition energies correspond to photon wavelengths within the visible spectrum (from $H_\alpha = 656 \text{ nm}$ to the series limit at 365 nm).
- This makes the Balmer series the only hydrogen emission series observable with the human eye and visible-light spectroscopy.

Why other options are incorrect:

- Option A:** Bohr's quantum model explains all hydrogen spectral series (Lyman, Paschen, Brackett, Pfund).
- Option B:** Hydrogen exhibits multiple series across the electromagnetic spectrum, including Lyman (UV) and Paschen (IR).
- Option D:** The Lyman series involves the lowest possible principal quantum number, terminating at $n = 1$.

Question #158 Key: (D)PHYSICS
16. Nuclear Physics

The SI unit of equivalent dose is:

CORE CONCEPT & DERIVATIONEquivalent dose scales absorbed physical radiation energy by dimensionless radiation weighting factors (W_R) to quantify biological damage to human tissue.

Formula / Rule / Reaction:

$$H = D \times W_R \implies \text{Units} = \frac{\text{Joules}}{\text{kilogram}} = \text{Sievert (Sv)}$$

Solution:

- The absorbed dose D is the physical energy deposited per unit mass of tissue, measured in grays (1 Gy = 1 J/kg).
- To account for the biological severity of different radiation types (such as alpha particles versus gamma rays), absorbed dose is multiplied by a radiation weighting factor W_R to obtain the equivalent dose H .
- The official SI derived unit for equivalent dose and effective dose is the sievert (Sv).

Why other options are incorrect:

- Option A:** The gray (Gy) is the SI unit of absorbed dose, not biologically weighted equivalent dose.
- Option B:** Mass is a base physical quantity measured in kilograms.
- Option C:** The rad is a non-SI legacy unit of absorbed dose (1 rad = 0.01 Gy).

Question #159 Key: (C)PHYSICS
16. Nuclear Physics

The decay rate of radioactive substance is:

CORE CONCEPT & DERIVATION

Radioactive decay is a first-order stochastic process where the activity is directly proportional to the number of undecayed nuclei remaining.

Formula / Rule / Reaction:

$$A(t) = -\frac{dN}{dt} = \lambda N(t) = \lambda N_0 e^{-\lambda t} = A_0 e^{-\lambda t}$$

Solution:

- The rate of disintegration (activity A) is governed by the differential law $dN/dt = -\lambda N$.
- Integrating this relationship yields an exponential decay equation: $A(t) = A_0 e^{-\lambda t}$.
- Therefore, the decay rate decreases exponentially with time.

Why other options are incorrect:

- Option A:** The decay rate decreases continuously as the parent nuclei are depleted over time.
- Option B:** Inverse proportionality ($1/t$) does not accurately model exponential nuclear decay kinetics.
- Option D:** Linear decrease would imply a constant rate of change and an absolute zero cutoff time, which contradicts the constant half-life of radioactive decay.

Question #160 Key: (D)PHYSICS
16. Nuclear Physics

The relation between gray and rad is given as: 1 Gy = _____ rad

CORE CONCEPT & DERIVATION

The gray (Gy) is the modern SI derived unit of absorbed radiation dose, while the rad is the historical CGS unit.

Formula / Rule / Reaction:

$$1 \text{ Gy} = 1 \text{ J/kg} \quad \text{and} \quad 1 \text{ rad} = 100 \text{ ergs/g} = 10^{-2} \text{ J/kg} = 0.01 \text{ Gy}$$

Solution:

- Equating the two unit definitions:

$$1 \text{ rad} = 10^{-2} \text{ Gy} \implies 1 \text{ Gy} = \frac{1}{10^{-2}} \text{ rad} = 100 \text{ rad}$$

- Therefore, one gray equals exactly 100 rads.

Why other options are incorrect:

- Option A:** 0.01 is the conversion factor for rads to grays (1 rad = 0.01 Gy).
- Option B:** 0.001 is a power-of-ten calculation error.
- Option C:** 10 is an incorrect scaling factor.

Question #161 Key: (A)PHYSICS
02. Force & Motion

The velocity-time plot for a moving particle shows a straight line. This means:

CORE CONCEPT & DERIVATION

The slope of a velocity versus time graph represents the instantaneous acceleration of the moving body.

Formula / Rule / Reaction:

$$a = \frac{dv}{dt} = \text{Slope of } v\text{-}t \text{ graph} = \text{Constant}$$

Solution:

- A straight line on a Cartesian graph is characterized by a single, constant gradient throughout its domain.
- Because the slope of a velocity-time plot corresponds to acceleration, a straight line indicates uniform, constant acceleration.

Why other options are incorrect:

- Option B:** A straight line with negative slope that crosses the time axis (from positive to negative velocity) represents a particle that slows down, stops, and reverses direction.
- Option C:** Displacement equals the area under the velocity-time curve, which is non-zero for any general straight line.
- Option D:** A linear slope directly indicates constant acceleration.

Question #162 Key: (C)PHYSICS
Q2. Force & Motion

A man is in a car that is moving with the velocity of 36 km/hr. His speed with respect to the car...

CORE CONCEPT & DERIVATION

Relative velocity describes the vector difference between the velocities of two bodies evaluated within a single frame of reference.

Formula / Rule / Reaction:

$$\vec{v}_{\text{man/car}} = \vec{v}_{\text{man/ground}} - \vec{v}_{\text{car/ground}}$$

Solution:

- The man is seated inside the moving vehicle, meaning he travels at the exact same velocity as the car relative to the ground:

$$\vec{v}_{\text{man}} = 36 \text{ km/h}, \quad \vec{v}_{\text{car}} = 36 \text{ km/h}$$

- Calculate his relative velocity with respect to the car frame:

$$\vec{v}_{\text{relative}} = 36 \text{ km/h} - 36 \text{ km/h} = 0 \text{ m/s}$$

Why other options are incorrect:

- Option A:** 10 m/s (which equals 36 km/h) is the speed of the man relative to a stationary observer on the ground, not relative to the car.
- Option B:** 36 m/s incorrectly mixes units (km/h converted directly as m/s).
- Option D:** Infinite relative speed is physically impossible in classical mechanics.

Question #163 Key: (B)PHYSICS
Q2. Force & Motion

On which car there is resultant force?

CORE CONCEPT & DERIVATION

According to Newton's First and Second Laws, a non-zero net resultant force is required whenever an object undergoes acceleration, which includes any change in the direction of velocity.

Formula / Rule / Reaction:

$$\Sigma \vec{F} = m\vec{a} \quad \text{and} \quad a_c = \frac{v^2}{r} \implies F_{\text{net}} = \frac{mv^2}{r} \neq 0$$

Solution:

- Velocity is a vector quantity with both magnitude (speed) and spatial direction.
- When a car rounds a curved path or bend, its direction of travel changes continuously, producing an inward radial centripetal acceleration.
- By Newton's second law, this centripetal acceleration requires a non-zero net resultant force supplied by tire-road lateral friction.

Why other options are incorrect:

- Option A:** A car moving along a straight horizontal road at constant velocity experiences zero net resultant force.
- Option C:** Moving uphill at a constant velocity represents uniform translational motion where driving force balances gravity and friction, yielding zero net resultant force.
- Option D:** A stationary car is in static equilibrium with zero net resultant force.

Question #164 Key: (B)PHYSICS
Q2. Force & Motion

If two equal masses are in motion with same individual speeds, we can conclude that:

CORE CONCEPT & DERIVATION

Linear momentum is a directional vector quantity, whereas kinetic energy is a scalar quantity.

Formula / Rule / Reaction:

$$\vec{p} = m\vec{v} \quad \text{and} \quad K = \frac{1}{2}mv^2$$

Solution:

- Because both bodies have identical masses ($m_1 = m_2$) and identical scalar speeds ($|\vec{v}_1| = |\vec{v}_2| = v$), their scalar kinetic energies are identical.
- However, linear momentum depends on the direction of travel. If the two masses move in different directions, their momentum vectors are not equal.
- Therefore, their momenta can be different from each other.

Why other options are incorrect:

- Option A:** Momenta are equal only if both bodies travel in the exact same direction.
- Option C:** Kinetic energies are scalars that depend solely on mass and speed; since both are equal, their kinetic energies must be identical.
- Option D:** Total energy includes potential energy, which varies with position in a field.

Question #165 Key: (B)PHYSICS
Q3. Work & Energy

The work done by a variable force can be found by dividing the:

CORE CONCEPT & DERIVATION

The work done by a position-dependent variable force is evaluated by dividing the total path into small displacement elements over which the force is approximately constant, then integrating.

Formula / Rule / Reaction:

$$W = \lim_{\Delta d_i \rightarrow 0} \sum_{i=1}^n F_i \cos \theta_i \Delta d_i = \int_{d_1}^{d_2} F(x) dx$$

Solution:

- When calculating work under a variable force, the total path is partitioned into a large number of small displacement intervals ($\Delta d_1, \Delta d_2, \dots, \Delta d_n$).
- Across each tiny displacement interval, the force remains essentially constant.
- Summing the work across all intervals yields the total work, which corresponds to the area under the force-displacement curve.

Why other options are incorrect:

- Option A:** Force is the dependent variable evaluated along the path, not the independent variable partitioned along the trajectory.
- Option C:** Dividing force itself into intervals is mathematically redundant because force values are set by position along the path.
- Option D:** Varying angular components without partitioning displacement does not yield the integral of work.

Question #166 Key: (B)

PHYSICS
03. Work & Energy

Two bodies with kinetic energies having a ratio of 4:1, are moving with equal linear momentum. ...

CORE CONCEPT & DERIVATION

For bodies with equal linear momentum, kinetic energy is inversely proportional to mass.

Formula / Rule / Reaction:

$$K = \frac{p^2}{2m} \Rightarrow m = \frac{p^2}{2K} \Rightarrow m \propto \frac{1}{K} \quad (\text{when } p \text{ is constant})$$

Solution:

- Let the kinetic energies be K_1 and K_2 with ratio $K_1/K_2 = 4/1$.
- Because both bodies have the same momentum p :

$$\frac{m_1}{m_2} = \frac{p^2/(2K_1)}{p^2/(2K_2)} = \frac{K_2}{K_1} = \frac{1}{4}$$

- Therefore, the ratio of their masses is 1 : 4.

Why other options are incorrect:

- Option A:** 1 : 2 represents the square root ratio of the masses, confusing velocity ratios with mass ratios.
- Option C:** 4 : 1 inverts the inverse relationship between mass and kinetic energy at fixed momentum.
- Option D:** 1 : 1 would require identical kinetic energies for equal momenta.

Question #167 Key: (D)

PHYSICS
03. Work & Energy

A fisherman lifts a fish of mass 250 g from rest through a vertical height of 1.8 m. The fish g...

CORE CONCEPT & DERIVATION

The total mechanical energy gained by an object lifted against gravity equals the sum of its acquired gravitational potential energy and translational kinetic energy.

Formula / Rule / Reaction:

$$\Delta E_{\text{total}} = \Delta U_g + \Delta K = mgh + \frac{1}{2}mv^2$$

Solution:

- Convert mass to standard SI units: $m = 250 \text{ g} = 0.25 \text{ kg}$.
- Calculate gravitational potential energy gained:

$$\Delta U_g = (0.25 \text{ kg})(9.8 \text{ m/s}^2)(1.8 \text{ m}) = 4.41 \text{ J}$$

- Calculate kinetic energy gained from rest:

$$\Delta K = \frac{1}{2}(0.25 \text{ kg})(1.1 \text{ m/s})^2 = \frac{1}{2}(0.25)(1.21) \approx 0.151 \text{ J}$$

- Sum the energy contributions:

$$\Delta E = 4.41 \text{ J} + 0.151 \text{ J} = 4.561 \text{ J} \approx 4.6 \text{ J}$$

Why other options are incorrect:

- Option A:** 0.15 J accounts only for the kinetic energy gain, omitting gravitational potential energy.
- Option B:** 4.3 J is an arithmetic underestimate.
- Option C:** 4.4 J accounts only for gravitational potential energy, omitting kinetic energy.

Question #168 Key: (C)

PHYSICS
04. Rotational & Circular Motion

One radian is analogous to:

CORE CONCEPT & DERIVATION

A radian is the plane angle subtended at the center of a circle by an arc whose length equals the radius of the circle.

Formula / Rule / Reaction:

$$\pi \text{ radians} = 180^\circ \Rightarrow 1 \text{ rad} = \frac{180^\circ}{\pi} \approx \frac{180^\circ}{3.14159265}$$

Solution:

- Evaluate the decimal degrees:

$$1 \text{ rad} \approx 57.29578^\circ$$

- Convert the fractional decimal part into arcminutes (where $1^\circ = 60'$):

$$0.29578 \times 60' = 17.747' \approx 18'$$

- Combining degrees and arcminutes gives: $57^\circ 18'$.

Why other options are incorrect:

- Option A:** $57^\circ 3'$ rounds 57.3° as 3 arcminutes rather than $0.3 \times 60 = 18$ arcminutes.
- Option B:** Uses arcseconds (") instead of arcminutes (').
- Option D:** Uses arcseconds (") rather than arcminutes (').

Question #169 Key: (B)

PHYSICS
02. Force & Motion

In the displacement-time graph, if the slope is constant then the velocity is

CORE CONCEPT & DERIVATION

The first derivative of displacement with respect to time represents velocity, which corresponds to the slope of a displacement-time curve.

Formula / Rule / Reaction:

$$v = \frac{dd}{dt} = \text{Slope of } d-t \text{ graph}$$

Solution:

- Because velocity is defined by the slope of the displacement-time graph, a constant slope indicates that the rate of change of displacement is uniform over time.
- Therefore, the object moves with constant (uniform) velocity, with zero acceleration.

Why other options are incorrect:

- Option A:** Variable velocity produces a curved displacement-time graph with a changing slope.
- Option C:** A constant slope uniquely defines constant velocity; it cannot be variable.
- Option D:** Infinite velocity corresponds to a vertical line on a displacement-time graph, which is physically impossible for massive particles.

Question #170 Key: (C)

PHYSICS
03. Work & Energy

An 8.0-kg box slides along a horizontal frictionless floor at 3 m/s and collides with a relativ...

CORE CONCEPT & DERIVATION

By the work-energy theorem, the kinetic energy of the box is absorbed through work done against the retarding spring force over the compression distance.

Formula / Rule / Reaction:

$$W = \vec{F} \cdot \vec{x} = \frac{1}{2}mv^2$$

Solution:

- Initial kinetic energy of the box:

$$K = \frac{1}{2}mv^2 = \frac{1}{2}(8.0 \text{ kg})(3 \text{ m/s})^2 = 4 \times 9 = 36 \text{ J}$$

- Convert compression to meters: $x = 12 \text{ cm} = 0.12 \text{ m}$.
- Calculate the average retarding force exerted by the spring:

$$\vec{F} = \frac{K}{x} = \frac{36 \text{ J}}{0.12 \text{ m}} = 300 \text{ N}$$

Why other options are incorrect:

- Option A:** 3 N is an arithmetic error.
- Option B:** 30 N represents an order-of-magnitude error in converting centimeters to meters.
- Option D:** 3000 N is ten times too large.

Question #171 Key: (B)

PHYSICS
04. Rotational & Circular Motion

The circular line has a fix distance from _____?

CORE CONCEPT & DERIVATION

A circle is defined in Euclidean geometry as the locus of all coplanar points that maintain a constant distance (the radius) from a designated central point.

Formula / Rule / Reaction:

$$(x - h)^2 + (y - k)^2 = r^2 \quad (\text{where } (h, k) \text{ is the fixed center})$$

Solution:

- The continuous circular line (circumference) is defined by its symmetry around a single fixed reference point: the center of the circle.
- Every point along this boundary line is located at the exact same radial distance r from this central point.

Why other options are incorrect:

- Option A:** The distance to an arbitrary point varies continuously around the perimeter.
- Option C:** Distance between a point on the circle and other perimeter points varies from zero to the diameter.
- Option D:** The distance to an exterior point changes across the circumference.

Question #172 Key: (C)

PHYSICS
04. Rotational & Circular Motion

If a particle is moving with uniform circular motion, then:

CORE CONCEPT & DERIVATION

In uniform circular motion, tangential speed is constant, meaning acceleration is entirely radial and acts perpendicular to the instantaneous velocity vector.

Formula / Rule / Reaction:

$$\vec{v} \cdot \vec{a}_c = |\vec{v}||\vec{a}_c| \cos(90^\circ) = 0 \implies \vec{v} \perp \vec{a}_c$$

Solution:

- The velocity vector ($\vec{v}$) is directed along the instantaneous tangent to the circular path at all times.
- The centripetal acceleration vector ($\vec{a}_c$) is directed radially inward toward the center of rotation.
- Because a circle's tangent is orthogonal to its radius, the velocity and acceleration vectors are perpendicular (90°).

Why other options are incorrect:

- Option A:** Antiparallel acceleration occurs during linear deceleration in a straight line.
- Option B:** Parallel acceleration occurs during linear acceleration along a straight path.
- Option D:** Acceleration is non-zero because the velocity vector changes direction continuously.

Question #173 Key: (B)

PHYSICS
04. Rotational & Circular Motion

One degree is equal to:

CORE CONCEPT & DERIVATION

Plane angle conversions relate one complete circular rotation of 360 degrees to 2π radians.

Formula / Rule / Reaction:

$$360^\circ = 2\pi \text{ radians} \implies 180^\circ = \pi \text{ radians} \implies 1^\circ = \frac{\pi}{180} \text{ radians}$$

Solution:

- A full circular revolution corresponds to 2π radians or 360 degrees.
- Dividing both sides by 180 yields:

$$1^\circ = \frac{\pi}{180} \text{ radians}$$

- (Note: "n" in the examination option text represents an unformatted symbol for the Greek letter π).

Why other options are incorrect:

- Option A:** $\pi/90$ radians equals 2° .
- Option C:** $\pi/270$ radians equals $2/3^\circ$.
- Option D:** $\pi/360$ radians equals 0.5° .

Question #174 Key: (B)PHYSICS
05. Waves

An observer standing near the sea shore observes 54 waves per minute. If the wavelength of the ...

CORE CONCEPT & DERIVATION

Wave velocity is the product of wave oscillation frequency and spatial wavelength.

Formula / Rule / Reaction:

$$v = f\lambda$$

Solution:

- Convert frequency from cycles per minute to hertz (cycles per second):

$$f = \frac{54 \text{ waves}}{60 \text{ s}} = 0.9 \text{ Hz}$$

- Given wavelength $\lambda = 10 \text{ m}$, calculate wave velocity:

$$v = (0.9 \text{ s}^{-1})(10 \text{ m}) = 9 \text{ m/s}$$

Why other options are incorrect:

- Option A:** 540 m/s fails to convert minutes to seconds (54×10).
- Option C:** 5.4 m/s represents an arithmetic division error.
- Option D:** 9 m/s is the correct evaluated option.

Question #175 Key: (B)PHYSICS
05. Waves

If the length of second pendulum becomes four times, then its time period will become:

CORE CONCEPT & DERIVATION

The period of a simple pendulum is directly proportional to the square root of its effective length.

Formula / Rule / Reaction:

$$T = 2\pi\sqrt{\frac{L}{g}} \Rightarrow T \propto \sqrt{L}$$

Solution:

- Let the initial period be T_1 with length L_1 .
- If length increases by a factor of 4 ($L_2 = 4L_1$):

$$T_2 = 2\pi\sqrt{\frac{4L_1}{g}} = 2(2\pi\sqrt{\frac{L_1}{g}}) = 2T_1$$

- Therefore, the time period doubles (becomes two times).

Why other options are incorrect:

- Option A:** Four times assumes an incorrect linear relationship between length and period.
- Option C:** Half would require reducing the length to one-fourth.
- Option D:** One-fourth would require reducing the length to one-sixteenth.

Question #176 Key: (B)PHYSICS
02. Idioms, Phrasal Verbs & Literary Figures

Choose the sentence that is grammatically correct:

CORE CONCEPT & DERIVATION

When the verb "weigh" denotes possessing a specified physical weight, it functions as a stative copular verb taking a direct measurement complement without a reflexive pronoun.

Formula / Rule / Reaction:

Subject + Weigh (linking/stative) + [Measurement Noun Phrase]

Solution:

- "He weighed two pounds" correctly uses "weighed" as an intransitive stative verb meaning "had a weight of".
- Inserting reflexive pronouns like "himself" incorrectly turns the verb into an active transitive action (placing oneself on a scale).

Why other options are incorrect:

- Option A:** "He weighed himself two pounds" incorrectly includes the redundant reflexive pronoun "himself".
- Option C:** "themselves" violates third-person singular subject-pronoun agreement with "He".
- Option D:** "itself" uses a neuter reflexive pronoun that does not agree with the masculine personal subject "He".

Question #177 Key: (B)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Choose the sentence that is grammatically correct:

CORE CONCEPT & DERIVATION

Stative verbs expressing dimension, measure, or mass take an adverbial objective complement directly without reflexive pronouns.

Formula / Rule / Reaction:

Correct : Subject + weighed + numeral + unit of measure

Solution:

- "He weighed two maunds" correctly pairs the subject with the stative verb and the quantified unit of mass ("two maunds").
- Reflexive pronouns are ungrammatical when expressing a passive physical attribute of mass.

Why other options are incorrect:

- Option A:** Omits the numerical quantifier before "maunds" and incorrectly includes "himself".
- Option C:** Lacks the unit of measure and uses the plural pronoun "themselves" with singular "He".
- Option D:** Uses the neuter pronoun "itself" to refer to a person.

Question #178 **Key: (C)**ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

Choose the correct option. We felt as if the ground was _____ beneath our feet.

CORE CONCEPT & DERIVATION

Standard English idiomatic usage uses the phrase "the ground slipping beneath one's feet" to describe feeling unstable, off-balance, or losing control.

Formula / Rule / Reaction:

Idiom : To feel the ground slipping beneath one's feet

Solution:

- The established figurative idiom for feeling unsteady or insecure is "the ground slipping beneath our feet".
- This captures the physical sensation of losing footing or stability.

Why other options are incorrect:

- **Option A:** "Digging" implies an active external excavation, which is unidiomatic here.
- **Option B:** While "sinking" describes quicksand or soft ground, "slipping" is the established standard idiom.
- **Option D:** "Bursting" denotes rupture under internal pressure, which does not fit the context of losing footing.

Question #179 **Key: (B)**ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

A few years ago, it _____ that human beings do not belong to this earth.

CORE CONCEPT & DERIVATION

Sentences introduced by the expletive pronoun "it" reporting past discoveries use passive voice with singular verb agreement.

Formula / Rule / Reaction:

Past Passive : It + was + past participle (V_3) + that-clause

Solution:

- The temporal adverbial "A few years ago" places the discovery in the simple past.
- Because the dummy subject "it" is singular and receives the action of discovery, the correct passive construction is "was found".

Why other options are incorrect:

- **Option A:** "Found" is active voice and would incorrectly imply that the pronoun "it" performed the action of finding.
- **Option C:** "Were found" uses a plural auxiliary verb that disagrees with the singular pronoun "it".
- **Option D:** "Had found" is an active past-perfect construction that lacks a passive auxiliary ("been").

Question #180 **Key: (A)**ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

A shoal of fish _____ killed by the fishermen.

CORE CONCEPT & DERIVATION

A collective noun acting as a single unified entity takes a singular verb, and passive constructions require a form of "to be" with the past participle.

Formula / Rule / Reaction:

Collective Noun (singular entity) + has been + past participle (V_3)

Solution:

- "A shoal" is a singular collective noun referring to a group of fish swimming together as a single body.
- The sentence requires a passive voice construction ("killed by the fishermen"), making "has been" the correct singular passive auxiliary.

Why other options are incorrect:

- **Option B:** "Have" uses a plural auxiliary and lacks the passive participle "been".
- **Option C:** "Had" alone is active voice and would incorrectly imply the fish performed the killing.
- **Option D:** "Has" alone is active voice and cannot precede the passive past participle "killed" without "been".

Question #181 **Key: (A)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

At last the fly was _____. The most appropriate word to be filled in is:

CORE CONCEPT & DERIVATION

Sentence completion requires contextual semantic coherence matching natural ecological relationships.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The relationship between a spider and a fly is predatory, centered on capturing prey in an orb web.
- The phrase "At last the fly was trapped by the spider" fits this predatory context and completes the passive construction appropriately.

Why other options are incorrect:

- **Option B:** "Entertained" personifies the relationship in a way that is contextually inappropriate for an objective assessment sentence.
- **Option C:** Spiders do not invite prey in a literal biological context.
- **Option D:** "Spared" is contextually less typical than capture in standard test bank passages based on Mary Howitt's fable.

Question #182 **Key: (C)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Choose the correct meaning of the underlined word: *Providentially*, his mind was not injured.

CORE CONCEPT & DERIVATION

Vocabulary in context evaluates word meaning through semantic derivation and recognized synonyms.

Formula / Rule / Reaction:

Providentially = By divine foresight or intervention $\Rightarrow$ Fortunately / Luckily

Solution:

- "Providentially" derives from "providence", referring to divine care or benevolent fortune.
- In this sentence, it modifies the clause to indicate that, by good fortune or luck, his mental faculties were spared from injury.
- Therefore, "Luckily" is the closest synonym.

Why other options are incorrect:

- **Option A:** "Slowly" refers to rate or speed, which does not relate to providence.
- **Option B:** "Suddenly" denotes quickness or surprise.
- **Option D:** "Unfortunately" is an antonym expressing adverse fortune.

Question #183 **Key: (A)**ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

A carpenter carves _____ on cab doors. Choose the right word to fill in the blank.

CORE CONCEPT & DERIVATION

Transitive verbs require a nominal direct object rather than a bare descriptive adjective.

Formula / Rule / Reaction:

Subject (carpenter) + Verb (carves) + Direct Object Noun (Arabesque)

Solution:

- The transitive verb "carves" requires a direct noun complement specifying what is being created.
- "Arabesque" functions as a noun denoting an intricate pattern of intertwined floral or geometric scrollwork.
- The remaining choices are adjectives that cannot stand alone as the direct object of "carves".

Why other options are incorrect:

- **Option B:** "Ornate" is an adjective meaning heavily decorated; it cannot function as a standalone noun direct object.
- **Option C:** "Decked" is a past participle or adjective meaning adorned.
- **Option D:** "Floral" is an adjective describing flower patterns, requiring a following noun like "designs" or "motifs".

Question #184 **Key: (B)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct option: _____ methods don't work.

CORE CONCEPT & DERIVATION

Demonstrative determiners must agree in number with the noun they modify.

Formula / Rule / Reaction:

Singular: This / That + [Singular Noun] vs. Plural: These / Those + [Plural Noun]

Solution:

- The noun "methods" is plural, as indicated by the plural inflection "-s" and the plural auxiliary contraction "don't" (do not).
- The plural demonstrative determiner "These" agrees with "methods".

Why other options are incorrect:

- **Option A:** "This" is singular and disagrees with the plural noun "methods".
- **Option C:** While "The" is grammatically possible, "These" is the specific demonstrative tested in this official item.
- **Option D:** "That" is singular and cannot modify plural "methods".

Question #185 **Key: (B)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

We just _____ a game of tennis.

CORE CONCEPT & DERIVATION

In standard English usage, the adverb "just" can modify the simple past tense to describe an immediately completed action.

Formula / Rule / Reaction:

Subject + just + Past Tense Verb (V_2)

Solution:

- The sentence describes a sporting activity completed shortly before the present moment.
- In the official test key, "had" functions as the past-tense main verb indicating that the game was recently concluded.

Why other options are incorrect:

- **Option A:** "Has" is singular and disagrees with the first-person plural subject "We".
- **Option C:** "Have" in the simple present tense fails to capture the completed nature of the game.
- **Option D:** While "have had" is common in British present perfect, the simple past "had" is the established official key answer.

Question #186 **Key: (A)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

The pen is expensive; still, I _____ it.

CORE CONCEPT & DERIVATION

Adversative conjunctive adverbs like "still" link an acknowledged concession to a completed past action.

Formula / Rule / Reaction:

Clause 1 (Present fact); still, + Clause 2 (Completed past action)

Solution:

- The semicolon and conjunctive adverb "still" indicate that despite the high cost of the pen, the speaker proceeded with the purchase.
- The simple past form "bought" describes this completed action.

Why other options are incorrect:

- **Option B:** "Will buy" describes future intent, whereas "still" in this frame typically contrasts a completed purchase against cost.
- **Option C:** "Have bought" is unnecessarily complex where the simple past is conventional.
- **Option D:** "Bought" is an ungrammatical regularization of the irregular verb "buy".

Question #187 Key: (A)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Punctuate the given sentence correctly. My father is Chairman of the Committee on Internal Rela...

CORE CONCEPT & DERIVATION

Two independent clauses without a coordinating conjunction cannot be joined without punctuation, and must be separated by a period or semicolon to avoid a run-on sentence.

Formula / Rule / Reaction:

Independent Clause 1 + Period (.) + Capitalized Independent Clause 2

Solution:

- "My father is Chairman of the Committee on Internal Relations" and "he also heads the Discipline Committee" are complete independent clauses.
- Placing a period between them and capitalizing "He" properly resolves the run-on sentence into two distinct sentences.

Why other options are incorrect:

- **Option B:** The dash creates an informal construction that is less standard than a period in formal writing.
- **Option C:** A colon is used to introduce an explanation, list, or amplification, which does not apply to this second duty.
- **Option D:** "But" incorrectly introduces a contrast where both statements describe leadership responsibilities.

Question #188 Key: (B)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Which of the following sentences is correct?

CORE CONCEPT & DERIVATION

Adverbial clauses of place are introduced by the subordinating conjunction "where" and join the main clause without intervening punctuation.

Formula / Rule / Reaction:

Main Clause + where + Subordinate Clause

Solution:

- "Where my parents live" functions as an essential adverbial clause of place modifying "to live".
- Essential adverbial clauses connect directly to the main clause without commas or colons.

Why other options are incorrect:

- **Option A:** "Near my parents live" is ungrammatical; "near" is a preposition that requires a noun phrase object ("near my parents") rather than an unlinked clause.
- **Option C:** Erroneously places a comma immediately after the subordinating conjunction "where".
- **Option D:** Incorrectly inserts a colon before the subordinate clause.

Question #189 Key: (D)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Read the following passage to answer the given question: Right after the Civil War, many distra...

CORE CONCEPT & DERIVATION

Reading comprehension infers historical allegiance from geographical origins referenced in a passage.

Formula / Rule / Reaction:

Birthplace: Piedmont of South Carolina $\Rightarrow$ Confederate allegiance (The South)

Solution:

- The passage states that Will Goodlad was a distraught soldier who returned to "the land of his birth, the Piedmont of South Carolina".
- In the context of the American Civil War, South Carolina was a southern Confederate state.
- Combined with the description that the war had devastated these soldiers and left them without homes, the passage indicates he fought for the South.

Why other options are incorrect:

- **Option A:** The "East" was not an opposing combatant side in the American Civil War.
- **Option B:** The "West" was the frontier region where soldiers migrated after the war, not a military combatant side.
- **Option C:** The North represents the Union army, which does not correspond to a native soldier from South Carolina returning to his devastated homeland.

Question #190 Key: (B)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Which part is the most appropriate to be filled in the blank? _____ so many people been out...

CORE CONCEPT & DERIVATION

Fronting a negative adverbial phrase requires subject-auxiliary inversion in the following main clause.

Formula / Rule / Reaction:

Negative Adverbial (Never before) + Auxiliary Verb (have) + Subject + Past Participle (been)

Solution:

- Starting with the negative restrictive phrase "Never before" requires inverted word order.
- The auxiliary verb "have" precedes the plural subject "so many people", followed by the past participle "been": "Never before have so many people been out of work as today".

Why other options are incorrect:

- **Option A:** "More than ever before" lacks the auxiliary verb "have" required by the participle "been".
- **Option C:** "In the past, there never have" produces an ungrammatical construction with "so many people been".
- **Option D:** "Formerly, there never were" cannot grammatically precede the past participle "been".

Question #191 Key: (A)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Spot the error in the given sentence: We try to speak with (A) one another (B) but (D) convey (...)

CORE CONCEPT & DERIVATION

Standard idiomatic English usage pairs the verb "speak" with specific prepositions depending on context, preferring "speak to" for direct communication.

Formula / Rule / Reaction:

Prescriptive rule : Speak to someone (direct address)

Solution:

- In formal prescriptive grammar tested in the provincial syllabus, the construction "speak to one another" is preferred over "speak with one another".
- Therefore, the error lies in bracketed word A ("with").

Why other options are incorrect:

- **Option B:** "One another" is correctly used for reciprocal action among more than two people.
- **Option C:** "Convey" is in the correct base form, sharing the subject "We" across the coordinating conjunction.
- **Option D:** "But" is the correct coordinating conjunction expressing contrast.

Question #192 Key: (D)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Choose the part of the sentence that carries error: In winter (A), the days (B) and nights (C) ...

CORE CONCEPT & DERIVATION

Compound subjects joined by the coordinating conjunction "and" take a plural verb.

Formula / Rule / Reaction:Subject₁ + and + Subject₂ = Plural Subject $\implies$ Requires Plural Verb (are)**Solution:**

- The subject consists of the compound noun phrase "the days and nights", which is plural.
- The singular linking verb "is" violates subject-verb agreement and must be corrected to the plural form "are": "In winter, the days and nights are cold".
- Thus, the error is in part D.

Why other options are incorrect:

- **Option A:** "In winter" is a standard prepositional phrase of time.
- **Option B:** "The days" is correctly formed as the first part of the compound subject.
- **Option C:** "And nights" correctly coordinates the second subject noun.

Question #193 Key: (C)ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

Choose the correct option. We felt as if the ground was _____ beneath our feet.

CORE CONCEPT & DERIVATION

The expression "the ground slipping beneath one's feet" is an established idiom describing a feeling of losing balance, security, or stability.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- This item reconciles the duplicate entry across the provincial test bank.
- "Slipping" is the established idiomatic choice, describing physical loss of traction or figurative instability.

Why other options are incorrect:

- **Option A:** "Digging" requires an active agent excavating the ground.
- **Option B:** While "sinking" is sometimes keyed in unofficial answer sheets, "slipping" is the accepted standard idiom.
- **Option D:** "Bursting" implies an explosive rupture from below.

Question #194 Key: (A)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Choose the sentence that carries an error regarding pronoun usage:

CORE CONCEPT & DERIVATION

Using a reflexive pronoun with an intransitive copular verb of measurement is ungrammatical.

Formula / Rule / Reaction:

Incorrect : Subject + weighed + reflexive pronoun + measure complement

Solution:

- When describing weight as a measurement, "weigh" does not take a reflexive object.
- "He weighed himself two maunds" incorrectly inserts "himself", making Option A the sentence containing the grammatical error.

Why other options are incorrect:

- **Option B:** "He weighed two maunds" is grammatically correct.
- **Option C:** "They weighed two maunds" correctly pairs a plural subject with the measurement.
- **Option D:** "She weighed two maunds" is grammatically correct.

Question #195 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

Categorical syllogisms are evaluated by set inclusion and Venn diagram overlap relationships.

Formula / Rule / Reaction:Premises : Children $\subseteq$ Silly, Silly $\cap$ Rich $\neq \emptyset$, Rich $\subseteq$ Big Shots**Solution:**

- Conclusion I: Since "All children are silly people" (Children $\subseteq$ Silly), the set of children is a non-empty subset of silly people. By conversion per accidens, "Some silly people are children" is necessarily true.
- Conclusion II: While some silly people are rich, there is no necessary overlap between the subset of children and the subset of rich people; thus Conclusion II is not necessarily true.
- Conclusion III: Since "Some silly people are rich" and "All rich people are big shots", the silly people who are rich must also belong to the set of big shots. Thus, "Some silly people are big shots" is necessarily true.
- Therefore, conclusions I and III are necessarily true.

Why other options are incorrect:

- **Option B:** Conclusion II cannot be deduced with certainty from the premises.
- **Option C:** Conclusion II is invalid.
- **Option D:** Includes the invalid Conclusion II.

Question #196 Key: (B)LOGICAL REASONING
11. Set Theory, Integer Bounds & Arithmetic

Read the following and choose the correct answer X, Y and Z are three whole numbers less than 3...

CORE CONCEPT & DERIVATION

Logical deduction applies specific arithmetic properties (prime, parity, bounds) to a defined finite set of integers.

Formula / Rule / Reaction:

$$\text{Domain: } \{n \in \mathbb{Z} \mid 23 < n < 31\} = \{24, 25, 26, 27, 28, 29, 30\}$$

Solution:

- Determine X: The prime numbers in the domain are restricted to $X = 29$ (since 23 and 31 are excluded by the strict inequalities).
- Determine Y: The odd numbers in the domain are $\{25, 27, 29\}$. The largest odd number within this allowed range is $Y = 29$.
- Determine Z: The even numbers in the domain are $\{24, 26, 28, 30\}$. The smallest even number within this range is $Z = 24$.
- Therefore, $X = 29$, $Y = 29$, and $Z = 24$.

Why other options are incorrect:

- **Option A:** 31 violates the constraint that numbers must be strictly less than 31.
- **Option C:** 23 violates the constraint that numbers must be strictly greater than 23.
- **Option D:** 27 is composite (3×9), not prime, and 26 is not the smallest even number in the range.

Question #197 Key: (D)LOGICAL REASONING
08. Letter Series & Coding-Decoding

Observe the pattern and select the next term in the sequence: SSSSS, SSRSS, SRQRS, RQPQR

CORE CONCEPT & DERIVATION

Pattern recognition sequences evaluate progressive letter substitutions following an alphabetical descending shift from the center outward.

Formula / Rule / Reaction:

$$\text{Alphabetical shifts: } S \rightarrow R \rightarrow Q \rightarrow P \rightarrow O$$

Solution:

- Term 1: SSSSS (baseline consisting of letter S).
- Term 2: SSRSS (center position 3 shifts backward one step in alphabet: $S \rightarrow R$).
- Term 3: SRQRS (positions 2, 3, 4 shift: position 3 becomes Q; positions 2 and 4 become R).
- Term 4: RQPQR (positions 1 through 5 shift: center becomes P; flanking positions become Q; outer positions become R).
- Term 5: Each letter shifts to the next preceding letter in the alphabet: outer $R \rightarrow Q$, next $Q \rightarrow P$, center $P \rightarrow O$, producing QPOPQ.

Why other options are incorrect:

- **Option A:** Contains "D", which does not fit the descending alphabetical pattern.
- **Option B:** Contains "OR", which breaks symmetry.
- **Option C:** Has 7 characters, violating the 5-character string length.

Question #198 Key: (D)LOGICAL REASONING
03. Courses of Action & Decision-Making

Read the following statement, assuming everything in it to be true. Then decide which of the gi...

CORE CONCEPT & DERIVATION

Courses of action in logical reasoning must represent proportionate, constructive responses rather than punitive or counterproductive actions.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Course I proposes yelling at a toddler over a genuine accident, which is developmentally inappropriate and counterproductive.
- Course II proposes punishing a toddler for an accidental mishap, which causes distress without teaching constructive motor control.
- Because neither action is constructive or developmentally sound, neither follows.

Why other options are incorrect:

- **Option A:** Yelling is counterproductive and disproportionate.
- **Option B:** Punishment for a genuine accident is inappropriate.
- **Option C:** Both suggested actions are flawed responses.

Question #199 Key: (B)LOGICAL REASONING
02. Cause and Effect Analysis

Read the following statements and identify the best cause and effect relation. I. State P start...

CORE CONCEPT & DERIVATION

Causal reasoning identifies a preceding policy or intervention (cause) that produces a documented subsequent societal outcome (effect).

Formula / Rule / Reaction:

$$\text{Cause (Rehabilitation programs)} \implies \text{Effect (Decrease in crime)}$$

Solution:

- Statement I describes the introduction of rehabilitation programs targeting unemployment, addiction, and lack of education.
- Statement II describes a steady reduction in crime rates across the same jurisdiction over the same period.
- Because rehabilitative social programs address the root economic and behavioral drivers of crime, Statement I is the direct cause and Statement II is its effect.

Why other options are incorrect:

- **Option A:** Decreased crime rates do not cause the state to establish addiction and job rehabilitation programs.
- **Option C:** The direct causal link between rehabilitation and crime reduction makes a common third cause less plausible.
- **Option D:** The temporal and geographical alignment points to a causal relationship rather than independent events.

Question #200 **Key: (A)**LOGICAL REASONING
Q4. Argument Evaluation & Ethics

Read the passage and the following statements below. Then choose the correct option, basing your...

CORE CONCEPT & DERIVATION

Critical reading comprehension requires deriving conclusions solely from explicit textual statements, without extrapolating beyond the provided evidence.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Statement i: The text states Pakistan is "rich in wildlife and culture", which does not establish that it is a wealthy country in financial terms.
- Statement ii: The passage mentions people from "most countries", which does not mean "all nationalities".
- Statement iii: The text explicitly mentions the "Indus River Dolphin", confirming that Pakistan is home to at least one dolphin species.
- Therefore, only statement iii is supported by the text.

Why other options are incorrect:

- **Option B:** Statements i and ii extrapolate beyond the text.
- **Option C:** Statement i is unsupported.
- **Option D:** Statement ii is unsupported.