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SZABMU ISLAMABAD

SZABMU Islamabad MDCAT 2024 Official Paper

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

🕒 Official Admitting Board: Shaheed Zulfikar Ali Bhutto Medical University Islamabad

📄 Archive Code: BEAMBE-FLP-SZABMU-2024

🕒 Duration: 200 Minutes (3h 20m)

200
TOTAL QUESTIONS

200m
OFFICIAL DURATION

+1 / 0.00
ZERO NEGATIVE MARKING

200
MAXIMUM MARKS

📄 EXAMINATION BLUEPRINT & SUBJECT WEIGHTAGE

Biology
68 MCQs
34.0% weight

Chemistry
54 MCQs
27.0% weight

Physics
54 MCQs
27.0% weight

English
18 MCQs
9.0% weight

Logical Reasoning
6 MCQs
3.0% weight

BIO SECTION: BIOLOGY

Questions 1 to 68 (68 MCQs)

Q1. BIO

Which one of the following is the main component of the lipid bilayer of the plasma membrane?

- (A) Acylglycerol
- (B) Lecithin
- (C) Triglyceride
- (D) Waxes

Q2. BIO

At which of the following stages of Prophase I does crossing over take place?

- (A) Diplotene
- (B) Leptotene
- (C) Pachytene
- (D) Zygotene

Q3. BIO

Which one of the following types of plastids helps in pollination and seed dispersal?

- (A) Amyloplast
- (B) Chloroplast
- (C) Chromoplast
- (D) Leucoplast

Q4. BIO

Which one of the following types of bonds is formed between the hydroxyl group of one amino acid and the hydrogen of the amino group of another amino acid with the release of water?

- (A) Ester bond
- (B) Glycosidic linkage
- (C) Peptide bond
- (D) Phosphodiester bond

Q5. BIO

How much delay is required in seconds for conductance from the S-A node to the A-V node?

- (A) 0.10
- (B) 0.15
- (C) 0.20
- (D) 0.30

Q6. BIO

Who purified filterable agents for the first time?

- (A) Charles Chamberland
- (B) Ivanowski
- (C) Louis Pasteur
- (D) Stanley

Q7. BIO

When neurotransmitter molecules bind to the receptors on the postsynaptic membrane, triggering an action potential in the postsynaptic neuron, by causing changes in its:

- (A) Concentrations of certain ion
- (B) Concentrations of hydrogen ion
- (C) Permeability of calcium ion
- (D) Permeability to certain ion

Q8. BIO

The living cells of cartilage are called:

- (A) Chondroblast
- (B) Chondroclasts
- (C) Chondrocytes
- (D) Osteocytes

Q9. BIO

When the diaphragm moves downward and the ribs move upward and outward, the volume in _____ increases while the pressure in _____ decreases.

- (A) Abdominal cavity, lungs
- (B) Chest cavity, lungs
- (C) Lungs, abdominal cavity
- (D) Lungs, chest cavity

Q10. BIO

Which one of the following is an acoelomate?

- (A) Aurelia
- (B) Chaetopterus
- (C) Euplectella
- (D) Taenia

Q11. BIO

What will be CO_2 fixation efficiency in plants with photorespiration?

- (A) 20%
- (B) 25%
- (C) 50%
- (D) 75%

Q12. BIO

Which one of the following conditions produces a sterile female with Turner's syndrome in humans but a sterile male in *Drosophila*?

- (A) XO
- (B) XXO
- (C) XXX
- (D) XXY

Q13. BIO

By the fusion of ilium, ischium, and pubis in the pelvic girdle, _____ is formed.

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

Q14. BIO

Sensation of pleasure, punishment, or sexual arousal are stimulated by which part of the brain?

- (A) Hippocampus
- (B) Hypothalamus
- (C) Amygdala
- (D) Thalamus

Q15. BIO

How much energy is present in the chemical bond of glucose that is converted into ATP by anaerobic respiration?

- (A) 2%
- (B) 4%
- (C) 10%
- (D) 36%

Q16. BIO

In the Calvin Cycle, the conversion of 5 molecules of Glyceraldehyde 3-phosphate into 3 molecules of Ribulose 1,5-bisphosphate by utilization of ATP is termed as:

- (A) CO₂ Fixation
- (B) Phosphorylation
- (C) Reduction
- (D) Regeneration

Q17. BIO

Movement of materials across plasma membrane of Amoeba, to engulf the liquid food is termed as:

- (A) Endocytosis
- (B) Exocytosis
- (C) Phagocytosis
- (D) Pinocytosis

Q18. BIO

Which of the following carbohydrates show red color with iodine solutions?

- (A) Cellulose
- (B) Glucose
- (C) Glycogen
- (D) Sucrose

Q19. BIO

At 25°C the concentration of each of H⁺ and OH⁻ ions in pure water is about _____ mole/liter.

- (A) 10⁻⁶
- (B) 10⁻⁷
- (C) 10⁻⁹
- (D) 10⁻¹⁴

Q20. BIO

Inner surface of cristae, in the mitochondrial matrix have many small knob-like structures, which are actually:

- (A) ATP synthetase
- (B) Coenzyme Q
- (C) Cytochromes
- (D) Mesosomes

Q21. BIO

When ovulation occurs during uterine cycle in human female?

- (A) After 6 days of start of menstruation
- (B) After 10 days of start of menstruation
- (C) After 14 days of start of menstruation
- (D) After 27 days of start of menstruation

Q22. BIO

In eukaryotic cells, autophagosomes are being originate from:

- (A) Endoplasmic reticulum
- (B) Golgi bodies
- (C) Mitochondria
- (D) Ribosomes

Q23. BIO

Which one of the following malfunctioned, organelles is mainly related to Tay-Sachs disease?

- (A) Endoplasmic reticulum
- (B) Glyoxysomes
- (C) Golgi bodies
- (D) Lysosomes

Q24. BIO

Which type of antibodies are present in the serum of the AB blood type?

- (A) Anti-A and anti-B antibodies
- (B) Anti-A antibodies
- (C) Anti-B antibodies
- (D) No antibodies at all

Q25. BIO

When 3 fatty acids combine with----- they form triglycerides and 3 molecules of water.

- (A) Alcohol
- (B) Ester
- (C) Glyceride
- (D) Glycerol

Q26. BIO

The science of discovery, identification, and interpretation of fossils by Darwin was----- evidence.

- (A) Biogeography
- (B) Chronology
- (C) Homology
- (D) Paleontology

Q27. BIO

Which one of the following is the end product in electron transport chain taking place at inner mitochondrial membrane?

- (A) Carbon dioxide
- (B) NADPH
- (C) Oxygen
- (D) Water

Q28. BIO

Which one of the following plants has modified bilobed leaves with a midrib between them, having long, stiff bristles along the margins of each lobe?

- (A) Dionaea muscipula
- (B) Drosera excelsa
- (C) Drosera intermedia
- (D) Nepenthes purpurea

Q29. BIO

In which one of the following types of dominance, genotypic and phenotypic ratios are same in the F1 generation?

- (A) Co-dominance
- (B) Complete dominance
- (C) Incomplete dominance
- (D) Over dominance

Q30. BIO

A covalently bonded inorganic ion with protein part of an enzyme is termed as _

- (A) Apoenzyme
- (B) Coenzyme
- (C) Holoenzyme
- (D) Prosthetic group

Q31. BIO

Which one of the following group of chemicals are used to kill or inhibit the growth of microorganisms in living tissues?

- (A) Antiseptics
- (B) Chemotherapeutics
- (C) Disinfectants
- (D) Vaccines

Q32. BIO

In Cyclic Photophosphorylation, which one of the following processes of light dependent reaction, of photosynthesis is NOT included?

- (A) Absorption of light
- (B) ATP synthesis
- (C) Photoexcitation
- (D) Photolysis of water

Q33. BIO

What is the range of carbon dioxide in the air?

- (A) 0.003–0.004%
- (B) 0.03–0.04%
- (C) 0.3–0.4%
- (D) 3–4%

Q34. BIO

Which one of the following cells produce the first polar body during oogenesis in female reproductive system?

- (A) Oogonia
- (B) Ovum
- (C) Primary oocytes
- (D) Secondary oocytes

Q35. BIO

Cyanides occupy the active site of enzymes by forming covalent bond, thus comes under the----- inhibitors.

- (A) Competitive
- (B) Irreversible
- (C) Non-competitive
- (D) Reversible

Q36. BIO

Which one of the following is the first electron acceptor from FADH₂ during electron transport chain?

- (A) Coenzyme Q
- (B) Cytochrome a
- (C) Cytochrome b
- (D) Cytochrome c

Q37. BIO

Which one of the following is an anaerobic bacterium?

- (A) Campylobacter
- (B) E. coli
- (C) Pseudomonas
- (D) Spirochete

Q38. BIO

Which one of the following hormones has a greater influence on peripheral vasoconstriction with a net effect in the rise of blood pressure?

- (A) Antidiuretic hormone
- (B) Epinephrine
- (C) Nor-epinephrine
- (D) Thyroid-stimulating hormone

Q39. BIO

At the end of the ileum, there is a sphincter that opens and closes from time to time to allow a small amount of residue to enter the large intestine.

- (A) Hepatic
- (B) Cardiac
- (C) Ileocolic
- (D) Pyloric

Q40. BIO

Which one of the following was key point of Darwinism?

- (A) Decent with modification
- (B) Endosymbiont hypothesis
- (C) Inheritance of acquired characters
- (D) Use and disuse of organs

Q41. BIO

Which one of the following chemicals in blood circulation is the cause of inflammation in the upper respiratory tract?

- (A) Acetyl amine
- (B) Ampicillin
- (C) Histamine
- (D) Tetracycline

Q42. BIO

Hemophilia type A and B zigzag from grandfather through a carrier daughter to a:

- (A) Maternal, granddaughter
- (B) Maternal, grandson
- (C) Paternal, granddaughter
- (D) Paternal, grandson

Q43. BIO

At which of the following reactions of glycolysis, ATP is NOT involved directly?

- (A) When 1,3-bisphosphoglycerate is converted into 3-phosphoglycerate
- (B) When fructose 6-phosphate is converted into fructose 1,6-bisphosphate
- (C) When glucose is converted into glucose 6-phosphate
- (D) When glyceraldehyde 3-phosphate is converted into 1,3-bisphosphoglycerate

Q44. BIO

Which one of the following is NOT a bacterium?

- (A) *Acanthureus nigrofuscus*
- (B) *Epulopiscium fishelsoni*
- (C) *Hyphomicrobium*
- (D) *Mycoplasma Spp*

Q45. BIO

Groups of ribosomes associated with the rough endoplasmic reticulum and the Golgi apparatus present in the cell body of neurons are termed

- (A) Axoplasm
- (B) Nissl's granules
- (C) Node of Ranvier
- (D) Polysomes

Q46. BIO

Lungs are covered with double-layered thin membranous tissue called

- (A) Epicardium
- (B) Larynx
- (C) Parabronchi
- (D) Pleura

Q47. BIO

Which one of the following monosaccharides is a hexose-aldehyde form of sugar?

- (A) Fructose
- (B) Galactose
- (C) Glucose
- (D) Ribose

Q48. BIO

In the roots, apoplast pathway becomes discontinuous in the endodermis due to the presence of

- (A) Casparian strips
- (B) Hydathodes
- (C) Pericyclic
- (D) Plasmodesmata

Q49. BIO

Which of the following glands is mainly related to the secretion of stress hormones?

- (A) Adrenal gland
- (B) Parathyroid gland
- (C) Pituitary gland
- (D) Thymus gland

Q50. BIO

Which one of the following organelles is ONLY present in Cyanobacteria?

- (A) Heterocyst
- (B) Lysosomes
- (C) Mitochondria
- (D) Ribosomes

Q51. BIO

Which of the following conjugate molecules are present as surfactants in respiratory distress syndrome?

- (A) Glycolipids
- (B) Glycoproteins
- (C) Lipopolysaccharides
- (D) Lipoproteins

Q52. BIO

In *Drosophila*, the heterozygote (w/w^+) exceeds in quantity of fluorescent pigment in eyes than wild (w^+/w^+) or white eye (w/w), this kind of dominance is termed as:

- (A) Co-Dominance
- (B) Complete Dominance
- (C) Incomplete Dominance
- (D) Over Dominance

Q53. BIO

In human testes, spermatozoa are present in:

- (A) Epididymis
- (B) Interstitial cells
- (C) Seminiferous tubules
- (D) Sertoli cells

Q54. BIO

Which one of the following types of phosphorylation occurs in electron transport chain, when NADH transfer electrons to coenzyme Q in inner mitochondrial membrane?

- (A) Cyclic Phosphorylation
- (B) Non-cyclic Phosphorylation
- (C) Oxidative Phosphorylation
- (D) Substrate level Phosphorylation

Q55. BIO

Gallstones are mostly made up of the following:

- (A) Calcium
- (B) Calcium phosphate
- (C) Cholesterol
- (D) Proteins

Q56. BIO

Which one of the following allows the exchange of RNA and protein between the nucleus and cytoplasm?

- (A) Nuclear matrix
- (B) Nuclear pores
- (C) Nucleolus
- (D) Nucleoplasm

Q57. BIO

The side of sheath attached to head region in bacteriophage is termed as:

- (A) Capsid
- (B) Collar
- (C) Core
- (D) End plate

Q58. BIO

During resting membrane potential, K^+ is higher in concentration inside than outside the membrane surface:

- (A) Ten-times
- (B) Fifteen-times
- (C) Twenty times
- (D) Twenty-five times

Q59. BIO

Which one of the following bones is NOT a part of the eye?

- (A) Ethmoid
- (B) Lacrimal
- (C) Sphenoid
- (D) Zygomatic

Q60. BIO

Lock and key model (1890), was modified by:

- (A) Emil Fischer
- (B) Erwin Chargaff
- (C) Koshland
- (D) Lorenz Oken

Q61. BIO

Which of the following part of phospholipids constitutes hydrophobic zone in plasma membrane?

- (A) Cholesterol
- (B) Fatty acid tail
- (C) Glycolipids
- (D) Phosphate head

Q62. BIO

Which of the following types of salivary glands are located behind the jaws?

- (A) Maxillary glands
- (B) Parotid glands
- (C) Sublingual glands
- (D) Submandibular glands

Q63. BIO

Which one of the following blood vessels has a larger bore, thin walls, and no pulse?

- (A) Aorta
- (B) Arteries
- (C) Capillaries
- (D) Veins

Q64. BIO

During which stage of bacteriophage replication, lysozyme is involved?

- (A) Adsorption
- (B) Attachment
- (C) Multiplication
- (D) Penetration

Q65. BIO

Which of the following proteins do not exhibit quaternary structure?

- (A) Actin
- (B) Haemoglobin
- (C) Insulin
- (D) Myoglobin

Q66. BIO

When a person is exposed to HIV, becomes ill but survives, as a result, the immunity developed against the disease is called:

- (A) Artificial Active Immunity
- (B) Artificial Passive Immunity
- (C) Natural Active Immunity
- (D) Natural Passive Immunity

Q67. BIO

Which one of the following sexually transmitted disease attack on T4 Lymphocytes?

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

Q68. BIO

When muscle contract, Z-line is _____, I-band _____ and H-zone disappear.

- (A) Closer, enlarged
- (B) Closer, shorten
- (C) Distant, enlarged
- (D) Distant, shorten

CHEM SECTION: CHEMISTRY

Questions 69 to 122 (54 MCQs)

Q69. CHEM

Which compound is used as a reference for calculating the extent of stability of benzene?

- (A) Cyclohexane
- (B) Cyclohexene
- (C) 1,3,5-cyclohexene
- (D) 1,3,5-cyclohexatriene

Q70. CHEM

When CO_2 reacts with propyl magnesium chloride followed by acid hydrolysis, the product formed is:

- (A) Butanoic acid
- (B) Ethanoic acid
- (C) Pentanoic acid
- (D) Propanoic acid

Q71. CHEM

What is the range of atomic numbers of the 3d series of transition elements?

- (A) 20–30
- (B) 21–30
- (C) 22–30
- (D) 24–30

Q72. CHEM

What will be the number of atoms in 2 moles of water molecule?

- (A) 6.02×10^{23}
- (B) 1.24×10^{24}
- (C) 1.92×10^{24}
- (D) 3.61×10^{24}

Q73. CHEM

Consider a reaction of A into B, if K value is 3×10^{-12} at 200°C then what will be the value of K at 250°C ?

- (A) $K = 9 \times 10^{-35}$
- (B) $K = 12 \times 10^{-35}$
- (C) $K = 6 \times 10^{-125}$
- (D) $K = 15 \times 10^{-125}$

Q74. CHEM

For boiling point, vapor pressure of liquid DOES NOT depend upon?

- (A) Amount of liquid
- (B) External atmospheric pressure
- (C) Intermolecular forces
- (D) Type of bond

Q75. CHEM

NaCl is an example of -----arrangement of crystal lattice.

- (A) Monoclinic
- (B) Octahedral
- (C) Tetrahedral
- (D) Triangular

Q76. CHEM

Formula for partial pressure calculation of any component in mixture of gases is ?

- (A) $P_i = P_t / X_i$
- (B) $P_i = P_t + X_i$
- (C) $P_i = P_t R$
- (D) $P_i = P_t X_i$

Q77. CHEM

What will be the internal energy of a system at constant volume?

- (A) $\Delta E = 0$
- (B) $\Delta E = q + P$
- (C) $\Delta E = q + P\Delta V$
- (D) $\Delta E = q_v$

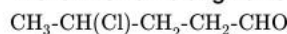
Q78. CHEM

Which of the following law helps to calculate the absolute temperature?

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

Q79. CHEM

The IUPAC name of given organic compound is:



- (A) 2-Chloropentanal
- (B) 2-Chloropentanol
- (C) 4-Chloropentanal
- (D) 4-Chloropentanol

Q80. CHEM

Which type of reaction will be occur, when an alcohol reacts with a carboxylic acid?

- (A) Dehydration reaction
- (B) Dehydrogenation reaction
- (C) Esterification reaction
- (D) Reduction reaction

Q81. CHEM

Diamagnetic behavior of Fluorine molecule is due to presence of

- (A) Paired electrons in d orbitals
- (B) Paired electrons in p orbitals
- (C) Unpaired electrons in d orbitals
- (D) Unpaired electrons in p orbitals

Q82. CHEM

Metallic character of alkaline earth metals -----down the groups.

- (A) Decreases
- (B) Gradually increases then decreases
- (C) Increases
- (D) Remains same

Q83. CHEM

Which of the following is the unit of rate of reaction?

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

Q84. CHEM

If percentage yield of chemical reaction is 60%, actual yield is 15g, what is its theoretical yield?

- (A) 18g
 (B) 20g
 (C) 25g
 (D) 30g

Q85. CHEM

The IUPAC name of Malonic acid $\text{CH}_2(\text{COOH})_2$ is:

- (A) 1,2-Ethanedioic acid
 (B) 1,3-Propanedioic acid
 (C) 1,4-Butanedioic acid
 (D) 1,6-Hexadecanoic acid

Q86. CHEM

What is the IUPAC name of given compound?



- (A) 5-Hexen-5-yne
 (B) 2-Hexen-6-yne
 (C) 4-Hexen-1-yne
 (D) Hex-2-en-5-yne

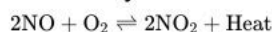
Q87. CHEM

Which of the following metal forms superoxide when reacted with oxygen?

- (A) Beryllium
 (B) Lithium
 (C) Magnesium
 (D) Potassium

Q88. CHEM

The chemical equilibrium given below will shift to the backward direction by:



- (A) Decreasing pressure and increasing temperature
 (B) Decreasing the temperature
 (C) Increasing the concentration of NO & O_2
 (D) Increasing the pressure

Q89. CHEM

Which of the following element will show electronic configuration of the outermost shell like ns^2, np^5 ?

- (A) C
 (B) Cl
 (C) S
 (D) Si

Q90. CHEM

What will be formula of work, when work is done on the system by the surrounding?

- (A) $W = -P/\Delta V$
 (B) $W = -P\Delta V$
 (C) $W = P/\Delta V$
 (D) $W = P\Delta V$

Q91. CHEM

Which product is formed by the reaction of phenol with concentrated nitric acid?

- (A) Adipic acid
 (B) m-Nitrophenol
 (C) Picric acid
 (D) p-Nitrophenol

Q92. CHEM

What is the percentage mass ratio of carbon and hydrogen in benzene?

- (A) 1:1
 (B) 3:1
 (C) 6:1
 (D) 12:1

Q93. CHEM

Transition element Vanadium mostly act as:

- (A) Amphoteric
 (B) Neutral
 (C) Oxidizing agent
 (D) Reducing agent

Q94. CHEM

Which type of redox reaction takes place at cathode of electrochemical cell?

- (A) Decomposition
 (B) Dissociation
 (C) Oxidation
 (D) Reduction

Q95. CHEM

Which type of catalyst is used during electrophilic substitution reactions of benzene?

- (A) Amphoteric
 (B) Lewis's acid
 (C) Lewis's base
 (D) Transition metals

Q96. CHEM

The correct stability order of M^{+4} cations is:

- (A) $\text{Ge}^{+4} < \text{Pb}^{+4} < \text{Sn}^{+4}$
 (B) $\text{Ge}^{+4} < \text{Sn}^{+4} < \text{Pb}^{+4}$
 (C) $\text{Ge}^{+4} > \text{Pb}^{+4} > \text{Sn}^{+4}$
 (D) $\text{Ge}^{+4} > \text{Sn}^{+4} > \text{Pb}^{+4}$

Q97. CHEM

Which type of isomerism is shown by fumaric acid and maleic acid?

- (A) Functional group isomers
 (B) Geometrical isomers
 (C) Optical isomers
 (D) Position isomers

Q98. CHEM

Primary alkyl halides nucleophilic substitution reaction involves:

- (A) 1st order kinetics
- (B) 2nd order kinetics
- (C) 3rd order kinetics
- (D) Zero order kinetics

Q99. CHEM

What will be the molarity of HCl solution with pH=4?

- (A) 0.0001M
- (B) 0.0004M
- (C) 0.004M
- (D) 4.0M

Q100. CHEM

If a weak acid is diluted with water, then the H⁺ ion concentration will:

- (A) Decrease
- (B) Gradually decreases, then increases
- (C) Increase
- (D) Remain same

Q101. CHEM

Which one the following is NOT an example of electrochemical cell?

- (A) Electrolytic cell
- (B) Photovoltaic cell
- (C) Solar cell
- (D) Voltaic cell

Q102. CHEM

The saturated alicyclic hydrocarbons have the general formula:

- (A) C_nH_{2n}
- (B) C_nH_{2n+1}
- (C) C_nH_{2n+2}
- (D) C_nH_{2n-2}

Q103. CHEM

If half-life of a chemical reaction is 30 minutes, how much time is required for its 87.5% completion?

- (A) 30 min
- (B) 60 min
- (C) 90 min
- (D) 120 min

Q104. CHEM

The oxidation of methanal results in the formation of:

- (A) Acetic acid
- (B) Formic acid
- (C) Methanol
- (D) Propanoic acid

Q105. CHEM

Which of the following metal hydroxide is the strongest base?

- (A) Ca(OH)₂
- (B) LiOH
- (C) Mg(OH)₂
- (D) NaOH

Q106. CHEM

Which one of the following molecules has zero dipole moment?

- (A) Ammonia
- (B) Carbon dioxide
- (C) Hydrogen fluoride
- (D) Water

Q107. CHEM

How many electron will be accommodate in the Subshell of Azimuthal quantum number $l = 2$?

- (A) 2
- (B) 6
- (C) 10
- (D) 12

Q108. CHEM

Which of the following mixtures will constitute the buffer solution?

- (A) Acetic acid & sodium acetate
- (B) Acetic acid & ammonia
- (C) Acetic acid and its ammonium acetate
- (D) Ammonia & ammonium acetate

Q109. CHEM

What will be the IUPAC name of neopentane?

- (A) 2,2-Dimethylpentane
- (B) 2,2-Dimethylpropane
- (C) 2-Methylbutane
- (D) 3-Methylbutane

Q110. CHEM

According to law of mass action, $K_p > K_c$ when reaction occurs with:

- (A) Decrease in volume on product side
- (B) Increase in volume on product side
- (C) Increase in volume on reactant side
- (D) Simultaneous increase and decrease of product

Q111. CHEM

The correct reactivity order of the following compounds towards nucleophile is:

- (A) H-CO-H < H-CO-R < R-CO-R
- (B) H-CO-H > H-CO-R > R-CO-R
- (C) H-CO-R < H-CO-H < R-CO-R
- (D) H-CO-H > R-CO-R > H-CO-R

Q112. CHEM

The anion derived by deprotonation of an alcohol acts:

- (A) Acidic moiety
- (B) Electrophile
- (C) Lewis acid
- (D) Lewis base

Q113. CHEM

Who stated that enthalpy change in a chemical reaction is same whether the reaction takes place in single step or in several steps?

- (A) Arrhenius' Law
- (B) Born Haber's Law
- (C) Dalton's Law
- (D) Hess's Law

Q114. CHEM

Which type of substituent will increase the acidic strength of phenols?

- (A) Electron donating substituents
- (B) Electron withdrawing substituents
- (C) Lewis's bases
- (D) Nucleophiles

Q115. CHEM

Water is liquid at room temperature as compared to ammonia and hydrogen disulphide due to presence of?

- (A) Co-ordinate covalent bond
- (B) Hydrogen bond
- (C) Ionic bond
- (D) Metallic bond

Q116. CHEM

Which of the following is an example of molecular solid?

- (A) Al_3N_2
- (B) CO_2
- (C) CsF
- (D) NaCl

Q117. CHEM

What will be mole ratio of Al to O_2 after balancing equation given below?



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

Q118. CHEM

Which product will be formed finally on the reduction of acetic acid with LiAlH_4 ?

- (A) Ethanal
- (B) Ethane
- (C) Ethanoic acid
- (D) Ethanol

Q119. CHEM

The melting and boiling point of alcohols are high as compared to corresponding alkanes due to:

- (A) Dipole-dipole interaction
- (B) Hydrogen bonding
- (C) Ionic interactions
- (D) Van der Waal interactions

Q120. CHEM

How many moles of oxygen gas are needed for combustion of 2 moles of propane?

- (A) 8
- (B) 10
- (C) 12
- (D) 14

Q121. CHEM

The e/m ratio of proton is that of an electron.

- (A) 1837 times greater than
- (B) Equal to
- (C) Greater than
- (D) Smaller than

Q122. CHEM

At constant volume, the heat supplied to a system is always equal to its:

- (A) Bond energy
- (B) Enthalpy change
- (C) Heat of sublimation
- (D) Internal energy change

PHY SECTION: PHYSICS

Questions 123 to 176 (54 MCQs)

Q123. PHY

The gradient/slope of I-V (Current-Potential) provides:

- (A) Conductance
- (B) Conductivity
- (C) Resistance
- (D) Resistivity

Q124. PHY

Under which condition Newton performed an experiment for calculation of speed of sound in air?

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

Q125. PHY

Which one of the following is a transverse wave?

- (A) Sound waves
- (B) Water waves
- (C) Waves associated with electron
- (D) Waves in spring

Q126. PHY

Diode is a/an _____ device which can be used for the rectification process.

- (A) Insulating
- (B) Perfect conducting
- (C) Perfect insulating
- (D) Semiconductor

Q127. PHY

The SI-unit of capacitance of capacitor is Farad, it can also be expressed as:

- (A) $A^2 s^2 / Nm$
- (B) $A^2 s^3 / Nm$
- (C) $A^3 s / Nm$
- (D) $A^2 s / Nm$

Q128. PHY

The strength of a radiation source is indicated by its activity measured in Becquerel. So, 10 Becquerel is equal to _____ decay per second.

- (A) 10
- (B) 100
- (C) 1000
- (D) 10000

Q129. PHY

If 60A current passes through a wire in 60 seconds. What will be the value of charge existing in the wire?

- (A) $4.6 \times 10^{-3} C$
- (B) $3.6 \times 10^{-3} C$
- (C) $2.6 \times 10^3 C$
- (D) $3.6 \times 10^3 C$

Q130. PHY

What will be the fundamental frequency in a stretched string, when it is plucked at a central point while it has a speed of 48 ms^{-1} with string length of 8m?

- (A) 3 Hz
- (B) 6 Hz
- (C) 9 Hz
- (D) 12 Hz

Q131. PHY

At what value of angle between the magnetic field intensity and vector area, the magnetic flux becomes zero?

- (A) 0°
- (B) 30°
- (C) 45°
- (D) 90°

Q132. PHY

The kinetic energy of emitted electrons in photoelectric effect can be increased by increasing _____

- (A) Applied potential of electrodes
- (B) Frequency of electromagnetic wave
- (C) Intensity of incident light
- (D) Momentum of incident photon

Q133. PHY

Which of the following rules helps us to detect the direction of angular velocity?

- (A) Head to tail rule
- (B) Kirchhoff rule
- (C) Left hand rule
- (D) Right hand rule

Q134. PHY

Which one of the following is the best condition for performing maximum work by any thermodynamic system?

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

Q135. PHY

The acceleration can be determined by the gradient of:

- (A) Displacement-Time graph
- (B) Force-time graph
- (C) Speed-time graph
- (D) Velocity-time graph

Q136. PHY

Alternating current generator is a device which is used to convert _____ into _____

- (A) Chemical energy, Electrical energy
- (B) Chemical energy, Mechanical energy
- (C) Electrical energy, Mechanical energy
- (D) Mechanical energy, Electrical energy

Q137. PHY

Electron-volt is the unit of:

- (A) Charge
- (B) Current
- (C) Electric potential
- (D) Energy

Q138. PHY

The electric flash attachment for a camera contains a capacitor for storing the energy used to produce the flash. In one such unit, the potential difference between the plates of 20 F capacitor is 5V.

Calculate the energy that is used to produce the flash?

- (A) 250 J
- (B) 310 J
- (C) 500 J
- (D) 650 J

Q139. PHY

Cancerous thyroid is treated:

- (A) Chlorine-36
- (B) Cobalt-60
- (C) Iodine-131
- (D) Radium-226

Q140. PHY

The rate of change of magnetic flux is measured in:

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

Q141. 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

Q142. PHY

The Lyman series contains the wavelengths in the hydrogen spectrum.

- (A) Far-infrared region
- (B) Infrared region
- (C) Ultraviolet region
- (D) Visible region

Q143. PHY

Rate of change of momentum is:

- (A) Impulse
- (B) Force
- (C) Torque
- (D) Velocity

Q144. PHY

If the slope of velocity-time graph gradually decreases, then the body is said to be moving with:

- (A) Positive acceleration
- (B) Negative acceleration
- (C) Uniform velocity
- (D) Zero acceleration

Q145. PHY

In the British Engineering system, the unit of power is horsepower. Numerically 1000 hp is equal to:

- (A) 7460 watts
- (B) 74600 watts
- (C) 746000 watts
- (D) 7460000 watts

Q146. PHY

Kilowatt hour is the commercial unit of electrical energy. 1Kwh is equal to _____

- (A) 3.6 meV
- (B) 3.6 MeV
- (C) 3.6 J
- (D) 3.6 MJ

Q147. PHY

If kinetic energy of a body becomes four times of the initial value, then the new momentum will:

- (A) Become twice of its initial value
- (B) Become three times of its initial value
- (C) Become four times of its initial value
- (D) Remain constant

Q148. PHY

The turns ratio of a step-up transformer is 5. A current of 20A is passed through its primary coil at 220V. Calculate the value of the volt in the secondary coil?

- (A) 1000V
- (B) 1025V
- (C) 1050V
- (D) 1100V

Q149. PHY

In any electric circuit, power output (P_{out}) will be maximum when _____ (Whereas R = External Resistance, r = Internal Resistance)

- (A) $R = 0$ but $r \neq 0$
- (B) $r = 0$ but $R \neq 0$
- (C) $R = \infty$ and $r = 0$
- (D) $R = r$

Q150. PHY

A man pulls a trolley through a distance of 50 m by applying a force of 100N, which makes an angle of 60° with the x-axis. Calculate the work done by the man ($\cos 60^\circ = 0.5$):

- (A) 2500 J
- (B) 5340 J
- (C) 6430 J
- (D) 7120 J

Q151. PHY

In an isothermal condition of any thermodynamic system, the change in internal energy:

- (A) Becomes maximum
- (B) Becomes minimum
- (C) Becomes zero
- (D) Remains constant

Q152. PHY

Which one of the following factors is the best for calculating Compton's shift?

- (A) Angular spin of electron
- (B) Energy of electron
- (C) Energy of photon
- (D) Scattering angle of photon

Q153. PHY

The instantaneous acceleration of an object travelling with uniform speed in a circle directed towards the centre of circle is referred as:

- (A) Centrifugal acceleration
- (B) Centripetal acceleration
- (C) Tangential acceleration
- (D) Angular acceleration

Q154. PHY

If the half-life of any radioactive nucleus is 0.693 years, what will be the value of decay constant?

- (A) 0.001 s^{-1}
- (B) 0.01 s^{-1}
- (C) 0.1 s^{-1}
- (D) 1 s^{-1}

Q155. PHY

Which one of the following is the SI-unit of angular displacement?

- (A) Degree
- (B) Radian
- (C) Revolution
- (D) Steradian

Q156. PHY

By increasing the temperature of medium about 1°C , the speed of sound is increased up to:

- (A) 0.41 ms^{-1}
- (B) 0.51 ms^{-1}
- (C) 0.61 ms^{-1}
- (D) 0.71 ms^{-1}

Q157. PHY

At what angle made by projectile with x-axis we can get 1/4th value of maximum height achieved by projectile?

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

Q158. PHY

Which one of the following materials has a negative temperature coefficient of resistance?

- (A) Copper
- (B) Germanium
- (C) Sulphur
- (D) Zinc

Q159. PHY

There is no net transfer of energy by particles of medium in:

- (A) Longitudinal wave
- (B) Progressive wave
- (C) Transverse wave
- (D) Stationary wave

Q160. PHY

In which of the following conditions, does the thermodynamic system DOES NOT perform any work?

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

Q161. PHY

At what angle made by scattered photons with x-axis, we can get the maximum value of Compton's shift?

- (A) 0°
- (B) 45°
- (C) 90°
- (D) 180°

Q162. PHY

Which of the following series of hydrogen spectrum lies in the visible region?

- (A) Balmer
- (B) Bracket
- (C) Lyman
- (D) Paschen

Q163. PHY

How many electrons are there in one Coulomb charge?

- (A) 6.25×10^{15}
- (B) 6.25×10^{16}
- (C) 6.25×10^{17}
- (D) 6.25×10^{18}

Q164. PHY

The SI-unit of magnetic flux is weber. Weber can also be expressed as:

- (A) Joule per ampere
- (B) Joule per coulomb
- (C) Newton per ampere
- (D) Newton per coulomb

Q165. PHY

The electrostatic force between two point-charges is independent of one of the following quantities.

- (A) Distance between charges
- (B) Magnitude of charges
- (C) Medium between charges
- (D) Temperature of charges

Q166. PHY

What will be the time period of wave generator if it produces 1000 waves in 10 seconds?

- (A) 0.001s
- (B) 0.01s
- (C) 0.02s
- (D) 0.1s

Q167. PHY

The quantity of motion present in a body can be measured by:

- (A) Acceleration
- (B) Momentum
- (C) Speed
- (D) Velocity

Q168. PHY

The SI-unit of relative permittivity is/has:

- (A) C^2/Nm^2
- (B) C^{-1}/Nm^{-2}
- (C) C^2/Nm
- (D) No Unit

Q169. PHY

A coil of 100 turns is linked by a flux of 20 mWb. If this flux is reversed in a time of 2 ms, calculate the average induced emf in the coil?

- (A) 1000 volts
- (B) 2000 volts
- (C) 3000 volts
- (D) 4000 volts

Q170. PHY

The Lenz's law of electromagnetic induction is in accordance with law of conservation of:

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

Q171. PHY

Which one of the following is the SI-unit of conventional current in a conductor?

- (A) Ampere
- (B) Coulomb
- (C) Ohm
- (D) Ohm metre

Q172. PHY

How much phase difference is required between two waves to form destructive interference?

- (A) 0°
- (B) 45°
- (C) 90°
- (D) 180°

Q173. PHY

Which one of the following is the unit of electric field intensity?

- (A) Newton per Ampere
- (B) Newton per volt
- (C) Volt per Coulomb
- (D) Volt per metre

Q174. PHY

A rotating pulley completes twelve revolutions in 4 seconds, calculate the average angular velocity rotating pulley in revolution per second?

- (A) 3
- (B) 4
- (C) 5
- (D) 6

Q175. PHY

Tesla is the SI-unit of magnetic field intensity. Tesla can also be expressed as:

- (A) $N^{-1}A^{-1}m^{-1}$
- (B) $N^{-1}A m^{-1}$
- (C) $NA^{-1}m^{-1}$
- (D) $NA m^{-1}$

Q176. PHY

In one dimensional elastic collision of two bodies of same masses, what will happen if the moving body collides with the mass which is initially at rest?

- (A) The collision would become inelastic
- (B) Their velocities will be interchanged
- (C) Their velocities will remain same
- (D) Velocities of both bodies will be zero

ENG SECTION: ENGLISH

Questions 177 to 194 (18 MCQs)

Q177. ENG

Supply the correct preposition:

I was almost back _____ my classroom door when I heard a strange noise.

- (A) At
- (B) By
- (C) In
- (D) To

Q178. ENG

Supply the correct form of verb:

Farah has planned _____ before the next term.

- (A) Resign
- (B) Resignation
- (C) Resigning
- (D) To resign

Q179. ENG

Identify the type of sentence given below:

The caliph noticed the merchant.

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

Q180. ENG

Supply the correct preposition:

Have you ever been in this company _____ six weeks?

- (A) During
- (B) For
- (C) Just
- (D) Since

Q181. ENG

Identify the correct indirect form for the sentence given below:

The speaker said to the audience, "Will you listen to me?"

- (A) The speaker asked the audience if they had listened to him.
- (B) The speaker asked the audience if they will listen to him.
- (C) The speaker asked the audience if they would listen to him.
- (D) The speaker asked the audience to listen to him.

Q182. ENG

Identify the correct spelling:

- (A) Discremination
- (B) Discrimination
- (C) Discrimination
- (D) Disscrimnation

Q183. ENG

Supply the correct antonym for the underlined word:

Your reckless behaviour is not acceptable. You have to be more:

- (A) Careful
- (B) Happy
- (C) Hardworking
- (D) Kind

Q184. ENG

Complete the sentence using the appropriate punctuation mark:

Punishment brings wisdom _____ it is the healing art of wickedness

- (A) ,
- (B) -
- (C) ;
- (D) :

Q185. ENG

Identify the figure of speech in the following sentence:

He is considered the black sheep of the family.

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

Q186. ENG

Supply the correct form of verb:

We had taken our meal before we _____

- (A) Had left
- (B) Have left
- (C) Left
- (D) Were leaving

Q187. ENG

Supply the correct antonym for the underlined word:

What can be done to alleviate the situation?

- (A) Aggravate
- (B) Anticipate
- (C) Clear
- (D) Manipulate

Q188. ENG

Supply the correct synonym for the underlined word.

An orthodox is a _____ person.

- (A) Clever
- (B) Confident
- (C) Confused
- (D) Conservative

Q189. ENG

Identify the correct passive form for the sentence given below:

The guard did not open the gate.

- (A) The gate did not open by the guard.
- (B) The gate had not been opened by the guard.
- (C) The gate was not being opened by the guard.
- (D) The gate was not opened by the guard.

Q190. ENG

Supply the correct synonym for the underlined word:

The new government brought stupendous changes in the economy and its critics.

- (A) Destroyed
- (B) Involved
- (C) Surprised
- (D) Fooled

Q191. ENG

The underlined part in the sentence adverbial clause of:

Although Mehran is hardworking, yet he failed.

- (A) Concession
- (B) Condition
- (C) Manner
- (D) Reason

Q192. ENG

Supply the correct form of verb:

Had I known the answer I _____ it.

- (A) Got written
- (B) Have written
- (C) Would have written
- (D) Wrote

Q193. ENG

The sentence "It was 97 in the shade." refers to the _____.

- (A) Age
- (B) Distance
- (C) Temperature
- (D) Year

Q194. ENG

Read the following passage to answer the given question:

"This is the way, Jess," said my father, pointing with his cane across the deep valley below us. "I want to show you something you've not seen for many years!" "Isn't it too hot for you to do much walking?" I wiped the streams of sweat from my face to keep them from stinging my eyes. I didn't want to go with him. I had just finished walking a half mile uphill from my home to his. I had carried a basket of dishes to Mom. There were two slips in the road and I couldn't drive my car and I knew how hot it was, It was 97 in the shade. I knew that from January until April my father had gone to eight different doctors. One of the doctors had told him to get a taxi to take him home. But my father walked home five miles across the mountain and told my Mom what the doctor had said. Forty years ago, a doctor had told him the same thing. And he had lived to raise a family of five children. He had done so much hard work in those years as any man.

The narrator has siblings?

- (A) Four
- (B) Five
- (C) Six
- (D) No

LOGIC SECTION: LOGICAL REASONING

Questions 195 to 200 (6 MCQs)

Q195. LOGIC

The high school maths department needs to appoint a new chairperson on the basis of seniority. Ms. Madiha is less senior than Mr. Tanvir but more than Ms. Aiyza. Mr. Rehan is more senior than Ms. Madiha but less than Mr. Tanvir. Mr. Tanvir doesn't want the job.

Who will be the new chairperson of the maths department?

- (A) Mr. Rehan
- (B) Mr. Tanvir
- (C) Ms. Aiyza
- (D) Ms. Madiha

Q196. LOGIC

What are the missing alphabets in the sequence EZFA, GBHY, IXJC, _____?

- (A) KDLW
- (B) KLDW
- (C) KWLD
- (D) LDKW

Q197. LOGIC

"All practical numbers are even" is a false statement then the true statement is _____

- (A) All practical numbers are odd
- (B) Some practical numbers are not even
- (C) Some practical numbers are even
- (D) Some practical numbers are not odd

Q198. LOGIC

In a group of 100 players, 70 play football, 50 play hockey, and 55 play cricket. 30 play both hockey and cricket, 25 play both football and hockey and 20 play all three games. How many players play both football and cricket?

- (A) 25
- (B) 30
- (C) 35
- (D) 40

Q199. LOGIC

A customer has filed a complaint about your product, stating it does NOT meet his expectation. What is your course of action?

- (A) Argue with the customer about the validity of their complaint
- (B) Customer complaint is not filed within the time limit
- (C) Offer a replacement
- (D) Tell the customer it's his fault for not using the product correctly

Q200. LOGIC

Statements:

I. Large numbers of people have fallen sick after consuming sweets from a particular shop in the locality.

II. Major part of the locality is flooded and has become inaccessible.

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

OFFICIAL VERIFIED ANSWER KEY

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[Online Portal >](#)

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

SUBJECT-WISE PERFORMANCE BREAKDOWN

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

PMDC PROVINCIAL MERIT FORMULA

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

Estimated Provincial Merit Aggregate: ----- %

PROPOLIS COGNITIVE ERROR AUTOPSIES

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

Question #1 Key: (B)

BIOLOGY
02. Biomolecules

Which one of the following is the main component of the lipid bilayer of the plasma membrane?

CORE CONCEPT & DERIVATION

The lipid bilayer consists predominantly of amphipathic phospholipids, of which phosphatidylcholine (lecithin) is the most abundant structural representative in animal plasma membranes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Lecithin contains a glycerol backbone, two hydrophobic fatty acid chains, and a hydrophilic choline-phosphate head group.
- This dual nature enables the spontaneous assembly of stable cellular bilayers in aqueous environments.

Why other options are incorrect:

- **Option A:** Acylglycerols lack the charged phosphate head required to establish the amphipathic barrier of membranes.
- **Option C:** Triglycerides are completely non-polar storage neutral lipids stored in adipocytes, not structural bilayer components.
- **Option D:** Waxes are protective hydrophobic coatings consisting of long-chain fatty acids esterified to long-chain alcohols.

Question #2 Key: (C)

BIOLOGY
15. Inheritance / Variation & Genetics

At which of the following stages of Prophase I does crossing over take place?

CORE CONCEPT & DERIVATION

Crossing over is the reciprocal exchange of non-sister chromatid genetic material that occurs within fully formed bivalents during meiotic prophase I.

Formula / Rule / Reaction:

Synapsis (Zygotene) → Recombination / Crossing Over (Pachytene) → Chiasmata Visibility (Diplotene)

Solution:

- During pachytene, recombination nodules containing recombinase enzyme complexes mediate the breakage, reciprocal swapping, and rejoining of maternal and paternal DNA segments.
- Synapsis is completed during zygotene, while physical separation of desynapsing homologues with visible chiasmata occurs later in diplotene.

Why other options are incorrect:

- **Option A:** Diplotene is characterized by the dissolution of the synaptonemal complex and the visual identification of chiasmata.
- **Option B:** Leptotene involves chromatin condensation and the appearance of bead-like chromomeres.
- **Option D:** Zygotene involves the initiation of homologous pairing and synaptonemal complex formation.

Question #3 Key: (C)

BIOLOGY
01. Cell

Which one of the following types of plastids helps in pollination and seed dispersal?

CORE CONCEPT & DERIVATION

Chromoplasts synthesize and store lipid-soluble carotenoid pigments (carotenes and xanthophylls) that impart yellow, orange, and red hues to plant structures.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The bright coloration provided by chromoplasts in floral petals attracts insect and avian pollinators.
- Similarly, pigmented ripe fruits signal nutritional readiness to frugivorous animals, promoting endozoochorous seed dispersal.

Why other options are incorrect:

- **Option A:** Amyloplasts are specialized non-pigmented leucoplasts that synthesize and store starch grains in roots and tubers.
- **Option B:** Chloroplasts contain chlorophyll pigments tailored specifically for capturing photonic energy during photosynthesis.
- **Option D:** Leucoplasts are colorless plastids dedicated to the storage of carbohydrates, lipids, or proteins.

Question #4 Key: (C)

BIOLOGY
02. Biomolecules

Which one of the following types of bonds is formed between the hydroxyl group of one amino aci...

CORE CONCEPT & DERIVATION

Polymerization of amino acids into polypeptides occurs through a condensation (dehydration synthesis) reaction between adjoining carboxyl and amino termini.

Formula / Rule / Reaction:



Solution:

- The carboxyl carbon of the first amino acid donates an –OH group while the α-amino nitrogen of the second donates an –H.
- Removal of water creates a covalent planar amide linkage termed a peptide bond (–CO–NH–).

Why other options are incorrect:

- **Option A:** An ester bond links an alcohol hydroxyl group with a carboxylic acid carboxyl group.
- **Option B:** A glycosidic linkage covalently connects two monosaccharide units via condensation.
- **Option D:** A phosphodiester bond links the 3-prime hydroxyl of one nucleotide sugar to the 5-prime hydroxyl of an adjacent nucleotide via a phosphate group.

Question #5 Key: (B)BIOLOGY
07. Circulation / Transport*How much delay is required in seconds for conductance from the S-A node to the A-V node?***CORE CONCEPT & DERIVATION**

Cardiac electrical impulses initiated by the sinoatrial (S-A) pacemaker undergo an intentional physiological transit delay before entering the ventricles.

Formula / Rule / Reaction:

$$\text{Total A-V Delay} \approx 0.15 \text{ s to } 0.16 \text{ s}$$

Solution:

- The action potential travels from the S-A node through the internodal pathways to the A-V node in approximately 0.03 s to 0.04 s.
- Within the A-V node and penetrating bundle fibers, conduction velocity slows drastically, imparting a cumulative transmission delay of approximately 0.15 s.
- This anatomical delay ensures that atrial systole empties blood completely into the ventricles before ventricular systole commences.

Why other options are incorrect:

- **Option A:** 0.10 s reflects only the isolated nodal conduction delay without incorporating the entire transit and transitional bundle component.
- **Option C:** 0.20 s exceeds normal physiological transit limits and denotes first-degree atrioventricular block.
- **Option D:** 0.30 s represents severe pathological conduction failure in cardiac tissue.

Question #6 Key: (D)BIOLOGY
05. Acellular Life*Who purified filterable agents for the first time?***CORE CONCEPT & DERIVATION**

Purification and crystallization of viral particles demonstrated that viruses possess discrete chemical structures composed of proteins and nucleic acids.

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

- In 1935, American biochemist Wendell M. Stanley isolated and crystallized the Tobacco Mosaic Virus (TMV).
- He proved that the purified crystalline material retained biological infectivity when inoculated onto healthy host tobacco plants.

Why other options are incorrect:

- **Option A:** Charles Chamberland developed the porcelain candle filter with sub-bacterial pore sizes.
- **Option B:** Dmitri Ivanowski discovered that the causal agent of tobacco mosaic disease passed through porcelain filters in 1892.
- **Option C:** Louis Pasteur formulated germ theory postulates and developed the rabies vaccine without isolating pure viral crystals.

Question #7 Key: (D)BIOLOGY
12. Nervous Coordination*When neurotransmitter molecules bind to the receptors on the postsynaptic membrane, triggering ...***CORE CONCEPT & DERIVATION**

Ligand-gated ion channels on the postsynaptic membrane transduce chemical signals into electrical responses by modifying membrane permeability.

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

- Neurotransmitter docking induces conformational opening of ligand-gated channel gates.
- This directly increases membrane permeability (P) to specific ions like Na^+ or K^+ , generating postsynaptic potentials.
- The primary causal biophysical change is the alteration in membrane permeability, which secondarily permits ion flux.

Why other options are incorrect:

- **Option A:** Bulk intracellular ion concentrations remain nearly constant; the generated depolarization relies on minimal ionic currents altering surface charge separation.
- **Option B:** Postsynaptic action potentials are not initiated by shifts in hydrogen ion (hydronium) gradients.
- **Option C:** Voltage-gated calcium permeability increases predominantly in the presynaptic terminal to initiate vesicle exocytosis, not on the postsynaptic membrane to launch action potentials.

Question #8 Key: (C)BIOLOGY
11. Support & Movement*The living cells of cartilage are called:***CORE CONCEPT & DERIVATION**

Cartilage is an avascular connective tissue containing specialized mature cellular units enclosed within fluid-filled matrix lacunae.

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

- Chondrocytes represent the mature, metabolically active living cells that maintain the extracellular collagenous and proteoglycan matrix of cartilage.
- They differentiate from chondroblasts once these precursor cells become entirely surrounded by self-secreted ground substance.

Why other options are incorrect:

- **Option A:** Chondroblasts are immature precursor cells located along the perichondrium that actively synthesize new cartilage matrix.
- **Option B:** Chondroclasts are multinucleated osteoclast-like cells involved in the resorption and degradation of calcified cartilage matrix.
- **Option D:** Osteocytes are mature bone cells embedded in osseous lacunae and connected via canaliculi.

Question #9 Key: (B)BIOLOGY
09. Respiration / Gaseous Exchange

When the diaphragm moves downward and the ribs move upward and outward, the volume in _____ inc....

CORE CONCEPT & DERIVATION

Pulmonary ventilation obeys Boyle's law; changes in the thoracic volume alter alveolar pressure relative to the external atmosphere.

Formula / Rule / Reaction:

$$P_1 V_1 = P_2 V_2 \quad (T = \text{constant})$$

Solution:

- Contraction of the diaphragm flattens it downward, while external intercostal contraction elevates the rib cage anteriorly and laterally.
- These coordinated actions increase the gross volume of the chest (thoracic) cavity.
- Expansion of the thoracic cavity lowers intrapulmonary pressure inside the lungs below atmospheric levels, drawing air inward.

Why other options are incorrect:

- **Option A:** Downward descent of the diaphragm increases pressure in the abdominal cavity while decreasing its volume.
- **Option C:** Inversion of anatomical spaces contradicts the physical direction of contraction.
- **Option D:** Pressure drops simultaneously inside both the intrapleural space and the lung alveoli; the cavity volume increases rather than decreases.

Question #10 Key: (D)BIOLOGY
09. Respiration / Gaseous Exchange

Which one of the following is an acoelomate?

CORE CONCEPT & DERIVATION

Triploblastic animals that lack a secondary fluid-filled body cavity between the gut and the outer body wall are classified under the grade Acoelomata.

Formula / Rule / Reaction:

Body Cavity Architecture: Triploblastic without coelom → Solid parenchyma filling mesoderm

Solution:

- ***Taenia*** (tapeworm) belongs to phylum Platyhelminthes, which are triploblastic acoelomate invertebrates.
- The space between their ectodermal body covering and endodermal gut lining is filled with solid mesodermal parenchyma tissue.

Why other options are incorrect:

- **Option A:** ***Aurelia*** (jellyfish) is a diploblastic cnidarian lacking a true mesoderm, placing it outside the triploblastic coelomate hierarchy.
- **Option B:** ***Chaetopterus*** is a marine polychaete annelid possessing a true, coelomate body cavity lined by mesodermal peritoneum.
- **Option C:** ***Euplectella*** (sponge) is an asymmetrical, parazoan organism lacking definite embryonic germ layers or body cavities.

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

What will be [Formula] fixation efficiency in plants with photorespiration?

CORE CONCEPT & DERIVATION

Photorespiration occurs when RuBisCO catalyzes the oxygenation of ribulose-1,5-bisphosphate instead of carboxylation, reducing net photosynthetic carbon assimilation.

Formula / Rule / Reaction:

$$\text{Net Efficiency} = 100\% - \text{Loss Due to Photorespiration} = 100\% - 25\% = 75\%$$

Solution:

- In typical C3 plants under moderate ambient temperatures, approximately one out of every four catalytic cycles of RuBisCO operates as an oxygenase reaction.
- This oxygenase diversion drains approximately 25% of the fixed carbon through the glycolate pathway.
- Consequently, net carbon fixation efficiency is reduced to approximately 75%.

Why other options are incorrect:

- **Option A:** 20% represents an erroneous arbitrary efficiency metric.
- **Option B:** 25% represents the proportion of fixed carbon wasted or lost due to photorespiratory oxygenation, not the remaining efficiency.
- **Option C:** 50% reflects severe thermal stress conditions, not baseline photorespiratory parameters outlined in the textbook.

Question #12 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics

Which one of the following conditions produces a sterile female with Turner's syndrome in human...

CORE CONCEPT & DERIVATION

Sex determination in humans depends on the presence of the Y-chromosome SRY gene, whereas in *Drosophila* it is governed by the ratio of X chromosomes to autosome sets (X:A ratio).

Formula / Rule / Reaction:

$$\text{Drosophila: } \frac{X}{A} = \frac{1}{2} = 0.50 \rightarrow \text{Male; Humans: } 45, X0 \rightarrow \text{Female (absence of Y)}$$

Solution:

- In humans, an individual with a single X chromosome and no Y chromosome (45,X0) develops as an anatomically sterile female with Turner's syndrome.
- In *Drosophila melanogaster*, an XO fly has an X:A ratio of 1 : 2 = 0.50, which directs male sexual development, but the absence of Y-linked fertility factors causes sterility.

Why other options are incorrect:

- **Option B:** XX0 is a non-standard chromosomal constitution not produced by routine meiotic non-disjunction.
- **Option C:** XXX produces metafemales (superfemales) in *Drosophila* (X : A = 1.5) and trisomy-X females in humans.
- **Option D:** XXY produces Klinefelter syndrome in humans (sterile male) and normal fertile females in *Drosophila* (X : A = 1.0).

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

By the fusion of ilium, ischium, and pubis in the pelvic girdle, _____ is formed.

CORE CONCEPT & DERIVATION

The three developmental bones of the os coxae fuse at the acetabulum through a temporary cartilaginous joint (synchondrosis) before undergoing complete adult ossification.

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

- During childhood and skeletal maturation, the ilium, ischium, and pubis are united at the cup-shaped acetabular fossa by hyaline growth cartilage.
- This union forms an immovable primary cartilaginous joint (synchondrosis) until late adolescence, when bony synostosis unites them into a single coxal bone.

Why other options are incorrect:

- **Option A:** A ball-and-socket synovial joint is formed between the assembled acetabular socket and the head of the femur, not by the developmental inter-bone junction itself.
- **Option C:** Fibrous joints (sutures, syndesmoses) link bones strictly through dense regular collagenous connective tissue without intervening hyaline cartilage.
- **Option D:** A hinge joint permits monoaxial movement in one plane, seen at the elbow and knee.

Question #14 Key: (C)BIOLOGY
12. Nervous Coordination

Sensation of pleasure, punishment, or sexual arousal are stimulated by which part of the brain?

CORE CONCEPT & DERIVATION

The limbic system regulates basic emotional behaviors, instinctual survival drives, and reward or punishment perception.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The amygdala, an almond-shaped nuclear complex located deep in the temporal lobe, processes intense basic emotions such as fear, anger, punishment, sexual arousal, and pleasure.
- It evaluates emotional valence and coordinates autonomic and behavioral output via connections to the hypothalamus.

Why other options are incorrect:

- **Option A:** The hippocampus processes spatial navigation and the consolidation of short-term information into long-term declarative memory.
- **Option B:** The hypothalamus oversees homeostatic drives (osmoregulation, body temperature, hunger, circadian rhythms) and neuroendocrine output.
- **Option D:** The thalamus serves as the sensory relay station routing incoming afferent impulses (except olfaction) to corresponding cortical areas.

Question #15 Key: (A)BIOLOGY
04. Bioenergetics

How much energy is present in the chemical bond of glucose that is converted into ATP by anaero...

CORE CONCEPT & DERIVATION

Anaerobic glycolysis achieves incomplete oxidation of glucose, capturing only a small fraction of its total chemical potential energy as high-energy phosphoanhydride bonds.

Formula / Rule / Reaction:

$$\text{Efficiency} = \frac{\text{Energy Conserved in ATP}}{\text{Total Free Energy of Glucose}} \times 100\% = \frac{2 \times 30.5 \text{ kJ/mol}}{2870 \text{ kJ/mol}} \times 100\% \approx 2.1\%$$

Solution:

- Complete aerobic oxidation of glucose yields approximately 2870 kJ/mol of free energy.
- Anaerobic glycolysis generates a net gain of only 2 ATP molecules per glucose, storing approximately 61.0 kJ of useful energy.
- Dividing 61.0 kJ by 2870 kJ indicates that approximately 2% of total glucose chemical bond energy is converted into ATP.

Why other options are incorrect:

- **Option B:** 4% overstates the thermodynamic recovery obtained from standard anaerobic substrate-level phosphorylation.
- **Option C:** 10% is an arbitrary distractor not matching any standard metabolic pathway efficiency.
- **Option D:** 36% to 40% represents the thermodynamic efficiency achieved under complete aerobic cellular respiration.

Question #16 Key: (D)BIOLOGY
04. Bioenergetics

In the Calvin Cycle, the conversion of 5 molecules of Glyceraldehyde 3-phosphate into 3 molecu...

CORE CONCEPT & DERIVATION

The Calvin-Benson cycle operates continuously by consuming triose phosphates to replenish the primary pentose acceptor substrate.

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

- Five molecules of glyceraldehyde 3-phosphate (G3P) undergo complex enzymatic rearrangements (transketolase and aldolase reactions) to yield three molecules of ribulose 5-phosphate.
- Phosphoribulokinase then uses three molecules of ATP to phosphorylate these pentoses, reforming three molecules of ribulose 1,5-bisphosphate (RuBP).
- This final operational phase is termed the regeneration phase of the Calvin cycle.

Why other options are incorrect:

- **Option A:** Carbon dioxide fixation is the initial carboxylation of RuBP catalyzed by RuBisCO to yield 3-phosphoglycerate.
- **Option B:** While kinase enzymes execute a phosphorylation step, the overall physiological phase is named regeneration.
- **Option C:** Reduction is the phase in which 1,3-bisphosphoglycerate is reduced to G3P using NADPH.

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

Movement of materials across plasma membrane of Amoeba, to engulf the liquid food is termed as:

CORE CONCEPT & DERIVATION

Endocytosis comprises distinct bulk transport mechanisms tailored specifically to the physical state of the ingested extracellular material.

Formula / Rule / Reaction:

$$\text{Pinocytosis} = \text{Cell Drinking (Fluid Droplets)}$$

Solution:

- Pinocytosis involves the non-specific invagination of the plasma membrane to form small endocytic vesicles enclosing droplets of liquid nutrient fluid.
- *Amoeba* uses this bulk fluid phase mechanism to ingest micro-droplets of surrounding aqueous solutions.

Why other options are incorrect:

- Option A:** Endocytosis is the broad category encompassing pinocytosis, phagocytosis, and receptor-mediated internalization.
- Option B:** Exocytosis is the active vesicular extrusion of macromolecules out of the cell into the external environment.
- Option C:** Phagocytosis is the selective ingestion of solid, particulate matter, such as bacteria or food particles, by pseudopodia.

Question #18 Key: (C)BIOLOGY
02. Biomolecules

Which of the following carbohydrates show red color with iodine solutions?

CORE CONCEPT & DERIVATION

Iodine tests detect the structural helicity of branched and unbranched homopolysaccharides.

Formula / Rule / Reaction:

Polyiodide-Complex: Starch → Blue-black; Glycogen → Red / Red-brown

Solution:

- Glycogen is a highly branched polymer of α -D-glucose with frequent $\alpha(1 \rightarrow 6)$ branch points every 8 to 12 residues.
- Because its short outer helical chains constrain polyiodide entrapment, it produces a characteristic red to reddish-brown coloration upon reaction with Lugol's iodine solution.

Why other options are incorrect:

- Option A:** Cellulose possesses linear $\beta(1 \rightarrow 4)$ unbranched chains stabilized by extensive hydrogen bonds that do not bind iodine, yielding no color.
- Option B:** Glucose is a monomeric monosaccharide unable to form polyiodide inclusion complexes.
- Option D:** Sucrose is a non-reducing disaccharide that does not react with iodine solution.

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

At 25°C the concentration of each of [Formula] and [Formula] ions in pure water is about -----

CORE CONCEPT & DERIVATION

Water undergoes auto-ionization to a small extent; at standard ambient conditions, the concentrations of hydrogen and hydroxide ions are equal.

Formula / Rule / Reaction:

$$K_w = [\text{H}^+][\text{OH}^-] = 1.0 \times 10^{-14} \quad (\text{at } 25^\circ\text{C})$$

Solution:

- In neutral pure water, the stoichiometry of ionization dictates:
- $[\text{H}^+] = [\text{OH}^-] = \sqrt{K_w} = \sqrt{1.0 \times 10^{-14}} = 1.0 \times 10^{-7} \text{ mol/L}$

Why other options are incorrect:

- Option A:** 10^{-6} mol/L reflects acidic water at elevated temperatures above 60°C .
- Option C:** 10^{-9} mol/L characterizes either a moderately alkaline solution or an erroneous exponent calculation.
- Option D:** 10^{-14} is the numeric value of the ionic product constant K_w , not the individual ion concentration.

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

Inner surface of cristae, in the mitochondrial matrix have many small knob-like structures, whi...

CORE CONCEPT & DERIVATION

The inner mitochondrial membrane contains multisubunit protein complexes that couple transmembrane proton flow to the catalytic synthesis of ATP.

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

- Electron microscopy reveals stalked elementary particles (Fernández-Morán particles or F_0F_1 complexes) projecting into the mitochondrial matrix.
- The spherical headpiece (F_1 catalytic subunit) functions as ATP synthetase (ATP synthase), generating ATP driven by proton flux through the membrane-embedded F_0 base channel.

Why other options are incorrect:

- Option B:** Coenzyme Q (ubiquinone) is a lipid-soluble, mobile electron carrier dissolved within the non-polar interior of the inner lipid bilayer.
- Option C:** Cytochromes are integral membrane hemoproteins embedded directly within respiratory complexes III and IV.
- Option D:** Mesosomes are artifactual or functional membranous invaginations found in prokaryotic bacterial cells, not eukaryotic mitochondria.

Question #21 **Key: (C)**BIOLOGY
14. Reproduction*When ovulation occurs during uterine cycle in human female?***CORE CONCEPT & DERIVATION**

In a typical 28-day human ovarian and menstrual cycle, the surge of luteinizing hormone triggers follicular rupture at the midpoint of the cycle.

Formula / Rule / Reaction:

$$\text{Day of Ovulation} = \text{Onset of Menstruation (Day 1)} + 14 \text{ Days}$$

Solution:

- Day 1 marks the onset of menstrual bleeding.
- The follicular phase extends for approximately 13 to 14 days, culminating in high estrogen feedback that induces an acute anterior pituitary LH surge.
- The LH surge triggers ovulation, releasing the secondary oocyte approximately 14 days after the onset of menstruation.

Why other options are incorrect:

- Option A:** Day 6 corresponds to the early proliferative phase, when endometrium regeneration begins under rising follicle-derived estrogen.
- Option B:** Day 10 represents the mid-proliferative phase during which Graafian follicle selection and maturation occur.
- Option D:** Day 27 represents the terminal ischemic/premenstrual stage characterized by corpus luteum involution.

Question #22 **Key: (B)**BIOLOGY
01. Cell*In eukaryotic cells, autophagosomes are being originate from:***CORE CONCEPT & DERIVATION**

In standard federal board curricula, the endomembrane system dictates that primary hydrolytic and degradative vesicles, including autophagic vacuolar membranes, are assembled and budded from the Golgi apparatus.

Formula / Rule / Reaction:

Endoplasmic Reticulum → Transport Vesicles → Golgi Complex → Autophagic Vacuole Formation

Solution:

- The Golgi bodies package hydrolytic enzymes into lysosomes and supply specialized membranes to isolate worn-out cellular organelles into autophagosomes.
- These membranes wrap around damaged mitochondria or peroxisomes, which then fuse with primary lysosomes to undergo macroautophagy.

Why other options are incorrect:

- Option A:** The rough and smooth endoplasmic reticulum synthesizes secretory proteins and lipids, but final sorting into discrete autophagic packaging occurs via the Golgi system in standard textbook keys.
- Option B:** Mitochondria are the targets of degradation during mitophagy, not the generating source of autophagosomal membranes.
- Option D:** Ribosomes are non-membranous ribonucleoprotein complexes responsible for protein translation and cannot generate vesicular membranes.

Question #23 **Key: (D)**BIOLOGY
01. Cell*Which one of the following malfunctioned, organelles is mainly related to Tay-Sachs disease?***CORE CONCEPT & DERIVATION**

Tay-Sachs disease is a congenital lysosomal storage disorder caused by the deficiency of a specific lysosomal acid hydrolase.

Formula / Rule / Reaction:

Deficient Hexosaminidase A → Accumulation of GM2 Ganglioside in Lysosomes

Solution:

- In Tay-Sachs disease, a genetic mutation results in the failure to produce functional β -hexosaminidase A inside lysosomes.
- Consequently, complex glycolipids (GM2 gangliosides) cannot be degraded and progressively accumulate within neuronal lysosomes, causing progressive neurodegeneration and cell death.

Why other options are incorrect:

- Option A:** The endoplasmic reticulum mediates protein folding, and its primary disorders involve unfolded protein responses, not ganglioside storage.
- Option B:** Glyoxysomes are plant-specific microbodies that operate the glyoxylate cycle for converting lipids to carbohydrates.
- Option C:** Golgi bodies modify and sort glycoproteins, but they are not the primary sites of destructive ganglioside accumulation.

Question #24 **Key: (D)**BIOLOGY
15. Inheritance / Variation & Genetics*Which type of antibodies are present in the serum of the AB blood type?***CORE CONCEPT & DERIVATION**

Under Landsteiner's rule, individuals do not produce circulating isoantibodies directed against the specific antigens present on their own erythrocyte membranes.

Formula / Rule / Reaction:

Antigens Present: A and B ⇒ Serum Antibodies: None

Solution:

- Type AB individuals possess both glycoprotein A and glycoprotein B agglutinogens on the surface of their red blood cells.
- To prevent self-agglutination, clonal deletion eliminates lymphocytes responsive to these self-antigens.
- Consequently, neither anti-A nor anti-B antibodies are present in the serum, making them universal red blood cell recipients.

Why other options are incorrect:

- Option A:** Anti-A and anti-B antibodies are both found in the serum of individuals with blood group O.
- Option B:** Anti-A antibodies are present in the serum of individuals with blood group B.
- Option C:** Anti-B antibodies are present in the serum of individuals with blood group A.

Question #25 Key: (D)BIOLOGY
02. Biomolecules

When 3 fatty acids combine with----- they form triglycerides and 3 molecules of water.

CORE CONCEPT & DERIVATION

Triglycerides (triacylglycerols) are neutral storage lipids formed by the triple esterification of long-chain fatty acids with a trihydroxy alcohol.

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

- Glycerol is a three-carbon molecule bearing three hydroxyl (–OH) functional groups.
- Each hydroxyl group reacts with the carboxyl group of a fatty acid via an ester linkage, releasing one molecule of water per bond (three molecules total).

Why other options are incorrect:

- Option A:** Alcohol is a generic chemical category; the specific required trihydric alcohol is glycerol.
- Option B:** An ester is the chemical bond produced by the reaction, not the starting substrate.
- Option C:** Glyceride is the general product name (monoglyceride, diglyceride, triglyceride), not the reactant precursor.

Question #26 Key: (D)BIOLOGY
16. Evolution

The science of discovery, identification, and interpretation of fossils by Darwin was-----evident...

CORE CONCEPT & DERIVATION

The study of ancient preserved anatomical remains, impressions, and petrified traces of historical organisms provides direct geological evidence for descent with modification.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Paleontology is the scientific discipline dedicated to the recovery, cataloging, anatomical analysis, and interpretation of fossilized organismal remains.
- Darwin relied on the fossil record (such as extinct South American armadillo and llama-like ungulate fossils) to substantiate macroevolutionary changes across chronological strata.

Why other options are incorrect:

- Option A:** Biogeography analyzes the geographical spatial distribution of extant and extinct species across planetary continents.
- Option B:** Chronology is the broad arrangement of events in order of temporal occurrence.
- Option C:** Homology is the comparative study of structural similarities derived from common ancestral descent.

Question #27 Key: (D)BIOLOGY
04. Bioenergetics

Which one of the following is the end product in electron transport chain taking place at inner...

CORE CONCEPT & DERIVATION

Molecular oxygen serves as the terminal electron acceptor in the respiratory electron transport chain, undergoing reduction to form metabolic water.

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

- Electrons flowing down complexes I through IV lose free energy that is conserved as an intermembrane proton gradient.
- At complex IV (cytochrome c oxidase), oxygen accepts four de-energized electrons along with four matrix protons to form two molecules of metabolic water.

Why other options are incorrect:

- Option A:** Carbon dioxide is produced upstream during pyruvate oxidation and the citric acid (Krebs) cycle within the mitochondrial matrix.
- Option B:** NADPH is an electron carrier synthesized in chloroplasts during photosynthetic light reactions and in the cytoplasmic pentose phosphate pathway.
- Option C:** Molecular oxygen is a consumed reactant, serving as the terminal acceptor rather than an end product.

Question #28 Key: (A)BIOLOGY
06. Digestion/Nutrition

Which one of the following plants has modified bilobed leaves with a midrib between them, havin...

CORE CONCEPT & DERIVATION

Carnivorous plants exhibit specialized foliar morpho-adaptations to trap arthropods for obtaining supplemental nitrogen in acidic, nutrient-deficient bogs.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- *Dionaea muscipula*** (Venus flytrap) features hinged, bilobed leaf blades connected by a central midrib.
- The outer margins of each lobe are fringed with long, interlocking marginal bristles (cilia), and the inner surface bears trigger hairs that initiate rapid leaf closure via thigmonastic turgor changes.

Why other options are incorrect:

- Option B:** ***Drosera*** species (sundews) have spoon-shaped or filiform leaves covered with sticky glandular tentacles rather than hinged bilobed blades.
- Option C:** ***Drosera intermedia*** captures prey via mucilaginous droplets on tentacles.
- Option D:** ***Nepenthes*** species form modified tubular pitchers with slippery rims and fluid reservoirs, not bilobed bristled leaves.

Question #29 **Key: (C)**BIOLOGY
15. Inheritance / Variation & Genetics

In which one of the following types of dominance, genotypic and phenotypic ratios are same in t...

CORE CONCEPT & DERIVATION

When an allele does not completely mask the expression of its alternate partner, heterozygous individuals develop an intermediate blended phenotype, making genotypic classes directly distinguishable.

Formula / Rule / Reaction:

F₂ Monohybrid Ratio: 1 Red (RR) : 2 Pink (Rr) : 1 White (rr) $\Rightarrow$ 1 : 2 : 1

Solution:

- Under incomplete dominance (e.g., *Mirabilis jalapa* flower color), the heterozygous Rr individual exhibits an intermediate pink phenotype.
- In a monohybrid cross, both the phenotypic and genotypic ratios in the resulting generation correspond identically to 1 : 2 : 1.

Why other options are incorrect:

- Option A:** In co-dominance, both alleles are fully expressed without blending (such as AB blood type); though its F₂ ratio is also 1 : 2 : 1, the canonical textbook question specifically refers to the classic intermediate blending example of incomplete dominance.
- Option B:** In complete dominance, homozygous dominant and heterozygous genotypes yield the same phenotype, generating a 3 : 1 phenotypic ratio compared to a 1 : 2 : 1 genotypic ratio.
- Option D:** In over-dominance, the heterozygote phenotype quantitatively exceeds both homozygous parental phenotypes (e.g., eye fluorescent pigment in *Drosophila*).

Question #30 **Key: (D)**BIOLOGY
03. Enzymes

A covalently bonded inorganic ion with protein part of an enzyme is termed as _

CORE CONCEPT & DERIVATION

Enzyme cofactors that are permanently and tightly integrated into the apoenzyme structure through covalent or strong coordinate bonds are defined as prosthetic groups.

Formula / Rule / Reaction:

Holoenzyme = Apoenzyme (Protein) + Prosthetic Group (Tightly Bound Cofactor)

Solution:

- When a non-protein component (whether an inorganic ion or an organic compound) is covalently bound to the protein core of an enzyme, it is designated as a prosthetic group.
- It remains permanently attached to the catalytic site throughout the catalytic cycle.

Why other options are incorrect:

- Option A:** An apoenzyme is the inactive, purely proteinaceous portion of an enzyme that requires a cofactor for catalytic activity.
- Option B:** A coenzyme is a loosely and transiently bound non-protein organic carrier molecule (e.g., NAD⁺, FAD).
- Option C:** A holoenzyme represents the fully assembled, catalytically active conjugated enzyme complex consisting of the apoenzyme plus its cofactor.

Question #31 **Key: (A)**BIOLOGY
08. Immunity

Which one of the following group of chemicals are used to kill or inhibit the growth of microor...

CORE CONCEPT & DERIVATION

Antimicrobial chemical agents are categorized based on their tissue toxicity and whether they are applied to living biological surfaces or inanimate objects.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Antiseptics are non-toxic, localized chemical formulations (e.g., chlorhexidine, iodine tincture) applied safely to living biological tissues and skin surfaces to inhibit or destroy pathogenic microorganisms.

Why other options are incorrect:

- Option B:** Chemotherapeutics are antimicrobial agents administered internally (systemically) to eradicate pathogens within bodily fluids and organs.
- Option C:** Disinfectants are harsh chemical compounds (e.g., phenol, chlorine bleach) applied strictly to inanimate surfaces because they cause tissue necrosis on living skin.
- Option D:** Vaccines are biological preparations of antigens designed to stimulate active, protective immunological memory, not direct chemical biocides.

Question #32 **Key: (D)**BIOLOGY
04. Bioenergetics

In Cyclic Photophosphorylation, which one of the following processes of light dependent reactio...

CORE CONCEPT & DERIVATION

Cyclic photophosphorylation utilizes Photosystem I exclusively, recycling excited electrons through the cytochrome *b₆f* complex without requiring external electron donors.

Formula / Rule / Reaction:

Photosystem I (P700) $\xrightarrow{h\nu}$ e^- $\rightarrow$ Ferredoxin $\rightarrow$ Cytochrome *b₆f* $\rightarrow$ Plastocyanin $\rightarrow$ P700

Solution:

- In cyclic electron transport, electrons emitted by P700 cycle back to the reaction center, establishing a proton-motive force across the thylakoid membrane that drives ATP synthesis.
- Photolysis of water occurs strictly at the oxygen-evolving complex of Photosystem II during non-cyclic photophosphorylation, meaning water splitting is absent in cyclic electron flow.

Why other options are incorrect:

- Option A:** Light absorption by chlorophyll *a* antenna pigments within Photosystem I is essential to drive the reaction.
- Option B:** ATP synthesis is the primary biological objective of cyclic photophosphorylation.
- Option C:** Photoexcitation of electrons within the P700 special pair by absorbed photons initiates the electron cycle.

Question #33 Key: (B)BIOLOGY
04. Bioenergetics

What is the range of carbon dioxide in the air?

CORE CONCEPT & DERIVATION

Earth's dry atmospheric air consists predominantly of nitrogen and oxygen, with carbon dioxide present as a trace gas.

Formula / Rule / Reaction:

$$\text{Atmospheric Fraction of CO}_2 \approx 300 \text{ to } 400 \text{ ppm} = 0.03\% \text{ to } 0.04\%$$

Solution:

- Standard textbook atmospheric compositions place carbon dioxide at approximately 0.03% to 0.04% by volume (equivalent to 300 to 400 parts per million).
- This ambient concentration provides the primary carbon reservoir for photosynthetic carbon fixation across the biosphere.

Why other options are incorrect:

- Option A:** 0.003% to 0.004% is an order of magnitude lower than the true atmospheric concentration.
- Option C:** 0.3% to 0.4% is tenfold higher than ambient atmospheric levels.
- Option D:** 3% to 4% reflects dangerously hypercapnic levels that are toxic to animal respiration.

Question #34 Key: (C)BIOLOGY
14. Reproduction

Which one of the following cells produce the first polar body during oogenesis in female reprod...

CORE CONCEPT & DERIVATION

Oogenesis involves unequal cytokinesis during meiosis I to conserve cytoplasmic volume and stored nutrients for the developing egg.

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

- The primary oocyte completes meiosis I just prior to ovulation under the influence of the pre-ovulatory LH surge.
- This reductional division produces one large functional haploid secondary oocyte and one small non-functional haploid first polar body.

Why other options are incorrect:

- Option A:** Oogonia are diploid germline stem cells that undergo mitotic proliferation during fetal life to form primary oocytes.
- Option B:** An ovum is the final mature haploid female gamete formed upon fertilization.
- Option D:** The secondary oocyte completes meiosis II only upon fertilization, generating the second polar body, not the first.

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

Cyanides occupy the active site of enzymes by forming covalent bond, thus comes under the-----.

CORE CONCEPT & DERIVATION

Inhibitors that bind permanently to catalytic groups of an enzyme through covalent bonds prevent dissociation, causing permanent inactivation.

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

- Cyanide ions form strong, permanent covalent bonds with the iron (Fe^{3+}) prosthetic group within the active site of cytochrome *c* oxidase.
- Because this covalent alteration cannot be reversed by dilution or substrate accumulation, cyanide functions as an irreversible inhibitor.

Why other options are incorrect:

- Option A:** Classical competitive inhibitors bind reversibly to the active site via weak non-covalent interactions (electrostatic, hydrogen bonds).
- Option C:** Non-competitive inhibitors typically bind reversibly to allosteric sites away from the active site without forming permanent covalent active-site bonds.
- Option D:** Reversible inhibitors establish an equilibrium and readily dissociate from the enzyme upon substrate addition or dilution.

Question #36 Key: (A)BIOLOGY
04. BioenergeticsWhich one of the following is the first electron acceptor from FADH₂ during electron transport...**CORE CONCEPT & DERIVATION**

Reducing equivalents from FADH₂ enter the mitochondrial electron transport chain at complex II and are passed to the inner membrane electron pool.

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

- Complex II (succinate dehydrogenase) contains bound FAD that extracts electrons from succinate to form FADH₂.
- These electrons are transferred through internal iron-sulfur (Fe-S) clusters directly to the mobile lipid carrier coenzyme Q (ubiquinone).

Why other options are incorrect:

- Option B:** Cytochrome *a* is a component of complex IV (cytochrome oxidase) that transfers electrons to molecular oxygen.
- Option C:** Cytochrome *b* is a constituent of complex III that accepts electrons downstream from reduced ubiquinone (CoQH₂).
- Option D:** Cytochrome *c* is a peripheral mobile carrier operating on the outer surface of the inner membrane between complexes III and IV.

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

Which one of the following is an anaerobic bacterium?

CORE CONCEPT & DERIVATION

Microorganisms are categorized by their atmospheric oxygen requirements for metabolic growth and cellular survival.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Many spirochetes (such as *Treponema pallidum**, the causative agent of syphilis) are obligate anaerobes or microaerophiles.
- They thrive in oxygen-depleted biological niches (e.g., deep mucosal layers and subgingival plaques) and lack catalase or superoxide dismutase.

Why other options are incorrect:

- Option A:** *Campylobacter** is microaerophilic, requiring small amounts of oxygen (5% O₂) for growth rather than anaerobic conditions.
- Option B:** *Escherichia coli** is a classic facultative anaerobe that preferentially performs aerobic respiration when oxygen is present.
- Option C:** *Pseudomonas aeruginosa** is an obligate aerobe that utilizes oxygen as its terminal electron acceptor.

Question #39 Key: (C)BIOLOGY
06. Digestion/Nutrition

At the end of the ileum, there is a sphincter that opens and closes from time to time to allow...

CORE CONCEPT & DERIVATION

Gastrointestinal sphincters maintain compartmental separation and regulate the unidirectional transit of chyme between consecutive digestive segments.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The ileocolic (ileocecocolic) sphincter sits at the junction connecting the terminal ileum of the small intestine to the cecum of the large intestine.
- It relaxes periodically to allow digested chyme to pass into the colon while preventing retrograde reflux of colonic bacteria into the small intestine.

Why other options are incorrect:

- Option A:** Hepatic refers to structures of the liver, which does not contain an intestinal boundary sphincter.
- Option B:** The cardiac (lower esophageal) sphincter regulates food passage from the esophagus into the stomach.
- Option D:** The pyloric sphincter controls the metered release of acidic chyme from the gastric antrum into the duodenum.

Question #38 Key: (C)BIOLOGY
13. Chemical Coordination

Which one of the following hormones has a greater influence on peripheral vasoconstriction with...

CORE CONCEPT & DERIVATIONAdrenergic receptor subtypes mediate differential vascular responses; α_1 -adrenergic receptor activation induces systemic vascular smooth muscle contraction.**Formula / Rule / Reaction:**Norepinephrine + α_1 -Adrenergic Receptors $\rightarrow$ Systemic Vasoconstriction $\rightarrow$ $\uparrow$ Total Peripheral Resistance (TPR) $\rightarrow$ $\uparrow$ BP**Solution:**

- Norepinephrine possesses predominant affinity for α_1 -adrenergic receptors located on peripheral arteriolar smooth muscle.
- Its release induces generalized systemic vasoconstriction, elevating total peripheral resistance and producing a rise in mean arterial blood pressure.

Why other options are incorrect:

- Option A:** Antidiuretic hormone (vasopressin) primarily stimulates water reabsorption via aquaporin-2 insertions in the renal collecting ducts, exerting potent vasoconstriction only at supraphysiological shock concentrations.
- Option B:** Epinephrine has higher affinity for β_2 -adrenergic receptors at physiological concentrations, inducing vasodilation in skeletal muscle beds and resulting in a lesser increase in total peripheral resistance.
- Option D:** Thyroid-stimulating hormone regulates thyroid follicular hormone synthesis without exerting acute direct vasomotor control.

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

Which one of the following was key point of Darwinism?

CORE CONCEPT & DERIVATION

Darwin formulated the theory of evolution based on natural selection operating upon pre-existing hereditary variations within populations.

Formula / Rule / Reaction:

Darwinian Evolution = Descent with Modification + Natural Selection

Solution:

- Darwin summarized evolution as descent with modification, expressing how ancestral lineages branch into new species through the accumulation of inheritable adaptations over geological time.

Why other options are incorrect:

- Option B:** The endosymbiont hypothesis was formulated by Lynn Margulis to explain the origin of mitochondria and plastids from engulfed prokaryotes.
- Option C:** The inheritance of acquired characters is the core postulate of Lamarckism, which Darwinian theory refuted.
- Option D:** The principle of use and disuse of organs is another Lamarckian premise proposing that physiological use directly directs adaptive evolutionary change.

Question #41 **Key: (C)**BIOLOGY
08. Immunity

Which one of the following chemicals in blood circulation is the cause of inflammation in the U...?

CORE CONCEPT & DERIVATION

Immediate allergic and inflammatory responses in the respiratory mucosa are mediated by vasoactive biogenic amines released from immune effector cells.

Formula / Rule / Reaction:

Mast Cell Degranulation $\rightarrow$ Histamine Release $\xrightarrow{H_1\text{-Receptor Binding}}$ Vasodilation + $\uparrow$ Capillary Permeability

Solution:

- Cross-linking of allergen-specific IgE on sensitized mast cells and basophils induces the rapid exocytosis of histamine.
- Histamine binds to H_1 endothelial receptors in nasal and mucosal tissues, causing local vasodilation, increased vascular permeability, edema, mucosal swelling, and rhinorrhea.

Why other options are incorrect:

- **Option A:** Acetylamine is an organic industrial chemical derivative not involved as an endogenous physiological mediator of mucosal inflammation.
- **Option B:** Ampicillin is a semisynthetic β -lactam antibiotic that inhibits bacterial cell wall synthesis.
- **Option D:** Tetracycline is a broad-spectrum antibiotic that inhibits bacterial protein synthesis by binding to the 30S ribosomal subunit.

Question #42 **Key: (B)**BIOLOGY
15. Inheritance / Variation & Genetics

Hemophilia type A and B zigzag from grandfather through a carrier daughter to a:

CORE CONCEPT & DERIVATION

X-linked recessive disorders exhibit a criss-cross (zigzag) transmission pattern because affected males pass their single mutated X chromosome exclusively to all their daughters.

Formula / Rule / Reaction:

Grandfather (X^hY) $\rightarrow$ Carrier Daughter ($X^H X^h$) $\rightarrow$ Grandson (X^hY) [$P = 50\%$]

Solution:

- A hemophilic grandfather (X^hY) transmits his mutated X chromosome to his obligate carrier daughter ($X^H X^h$).
- The carrier daughter has a 50% chance of passing this mutated X chromosome to her sons, who express the hemophilia phenotype as maternal grandsons because they have no second X chromosome.

Why other options are incorrect:

- **Option A:** A maternal granddaughter would require an additional mutant X chromosome from her father to express the full recessive hemophilic phenotype.
- **Option C:** A grandfather passes his Y chromosome to his sons, who cannot inherit his X chromosome or transmit it to a paternal granddaughter.
- **Option D:** Transmission through the father requires passing a Y chromosome to the son, which breaks the transmission path for X-linked alleles.

Question #43 **Key: (D)**BIOLOGY
04. Bioenergetics

At which of the following reactions of glycolysis, ATP is NOT involved directly?

CORE CONCEPT & DERIVATION

Enzymes of the glycolytic pathway couple reactions using either substrate-level nucleotide transfer (kinases) or oxidative phosphorylation with inorganic phosphate (dehydrogenases).

Formula / Rule / Reaction:

$G3P + NAD^+ + P_i \xrightarrow{G3P\text{ Dehydrogenase}} 1,3\text{-BPG} + NADH + H^+$

Solution:

- The conversion of glyceraldehyde 3-phosphate (G3P) to 1,3-bisphosphoglycerate (1,3-BPG) is catalyzed by glyceraldehyde 3-phosphate dehydrogenase (GAPDH).
- This reaction consumes free inorganic phosphate (P_i) and reduces NAD^+ to NADH without consuming or synthesizing ATP.

Why other options are incorrect:

- **Option A:** Phosphoglycerate kinase directly generates one ATP molecule from ADP via substrate-level phosphorylation.
- **Option B:** Phosphofructokinase-1 directly consumes one ATP molecule to phosphorylate fructose 6-phosphate.
- **Option C:** Hexokinase directly consumes one ATP molecule to phosphorylate glucose into glucose 6-phosphate.

Question #44 **Key: (A)**BIOLOGY
16. Evolution

Which one of the following is NOT a bacterium?

CORE CONCEPT & DERIVATION

Biological binomial nomenclature identifies distinct organismal taxa spanning divergent domains of life.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- *Acanthurus nigrofusus** (the brown surgeonfish) is a marine vertebrate fish belonging to family Acanthuridae.
- It serves as the intestinal host for the giant symbiotic bacterium *Epulopiscium fishelsoni**, but the fish itself is a multicellular chordate.

Why other options are incorrect:

- **Option B:** *Epulopiscium fishelsoni** is a giant gram-positive prokaryotic bacterium that reaches up to 600 micrometers in length.
- **Option C:** *Hyphomicrobium** is a prosthecate, budding gram-negative bacterium found in aquatic environments.
- **Option D:** *Mycoplasma** species are wall-less, pleomorphic bacteria noted as some of the smallest self-replicating prokaryotes.

Question #45 **Key: (B)**BIOLOGY
12. Nervous Coordination

Groups of ribosomes associated with the rough endoplasmic reticulum and the Golgi apparatus pre...

CORE CONCEPT & DERIVATION

Somatic neuronal cytoplasm contains basophilic staining structures dedicated to high-volume neurotransmitter and structural protein synthesis.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Nissl's granules (Nissl bodies) consist of dense aggregations of rough endoplasmic reticulum rosettes with clusters of free and bound polyribosomes.
- They are abundant in the neuronal perikaryon and proximal dendrites to support continuous protein synthesis, but are absent from the axon hillock and axon proper.

Why other options are incorrect:

- **Option A:** Axoplasm refers to the specialized cytoplasm contained within the cylindrical axon shaft.
- **Option C:** Nodes of Ranvier are regular unmyelinated interruptions along a myelinated axon where voltage-gated sodium channels concentrate.
- **Option D:** Polysomes are linear strands of multiple ribosomes translating a single mRNA; while they occur within Nissl bodies, the specialized neuronal aggregates are specifically termed Nissl's granules.

Question #46 **Key: (D)**BIOLOGY
09. Respiration / Gaseous Exchange

Lungs are covered with double-layered thin membranous tissue called

CORE CONCEPT & DERIVATION

Each lung is enclosed within an invaginated, double-layered serous sac that minimizes friction and couples pulmonary expansion to the movements of the thoracic wall.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The pleura consists of two continuous layers: the inner visceral pleura tightly adhering to the lung surface, and the outer parietal pleura lining the internal chest wall and diaphragm.
- The thin intervening pleural cavity contains serous pleural fluid that prevents frictional abrasion during continuous respiratory cycles.

Why other options are incorrect:

- **Option A:** The epicardium is the outer serous visceral layer covering the myocardium of the heart.
- **Option B:** The larynx is the cartilaginous organ located superior to the trachea that houses the vocal cords.
- **Option C:** Parabronchi are thin-walled, non-collapsible gas exchange channels found in the lungs of birds.

Question #47 **Key: (C)**BIOLOGY
02. Biomolecules

Which one of the following monosaccharides is a hexose-aldehyde form of sugar?

CORE CONCEPT & DERIVATION

Monosaccharides are classified based on the number of carbon atoms in their backbone and whether their carbonyl group is an aldehyde or a ketone.

Formula / Rule / Reaction:

Aldohexose Formula: $\text{CHO}-(\text{CHOH})_4-\text{CH}_2\text{OH}$ ($\text{C}_6\text{H}_{12}\text{O}_6$)

Solution:

- Glucose contains a chain of six carbon atoms (hexose) with a terminal aldehyde group at carbon-1 in its open-chain Fischer projection.
- This structure defines it as the prototypical aldohexose (hexose-aldehyde) in biological metabolism.

Why other options are incorrect:

- **Option A:** Fructose is a ketohexose, containing six carbon atoms with a ketone carbonyl group at carbon-2.
- **Option B:** Galactose is also an aldohexose stereoisomer (C-4 epimer of glucose); however, the standard national curriculum highlights glucose as the primary aldohexose reference in bioenergetics.
- **Option D:** Ribose is an aldopentose, containing five carbon atoms in its backbone.

Question #48 **Key: (A)**BIOLOGY
07. Circulation / Transport

In the roots, apoplast pathway becomes discontinuous in the endodermis due to the presence of

CORE CONCEPT & DERIVATION

Roots regulate radial mineral and water transport into the vascular stele through specialized waterproof suberin barriers located in the endodermis.

Formula / Rule / Reaction:

Apoplastic Route $\xrightarrow{\text{Blocked by Casparian Strip}}$ Transmembrane / Symplastic Route

Solution:

- The apoplast pathway involves passive diffusion through continuous cell wall matrices and intercellular spaces.
- At the root endodermal cylinder, radial and transverse cell walls contain Casparian strips composed of hydrophobic suberin and lignin.
- This impermeable band halts continuous apoplastic movement, forcing water and dissolved mineral ions across the plasma membrane into the symplast for selective uptake.

Why other options are incorrect:

- **Option B:** Hydathodes are specialized foliar vascular structures that exude water droplets during guttation.
- **Option C:** The pericycle is a cylinder of parenchymatous or sclerenchymatous cells located inside the endodermis that gives rise to lateral roots.
- **Option D:** Plasmodesmata are microscopic cytoplasmic channels that connect adjacent plant cells to establish the continuous symplastic pathway.

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

Which of the following glands is mainly related to the secretion of stress hormones?

CORE CONCEPT & DERIVATION

The neuroendocrine response to acute and chronic stress is orchestrated primarily by the paired adrenal glands situated atop the kidneys.

Formula / Rule / Reaction:

Stress: Sympathetic → Adrenal Medulla (Epi/NE); ACTH → Adrenal Cortex (Cortisol)

Solution:

- The adrenal medulla secretes catecholamines (epinephrine and norepinephrine) to launch rapid fight-or-flight sympathetic responses during acute stress.
- The adrenal cortex secretes glucocorticoids (cortisol) via the hypothalamic-pituitary-adrenal axis to manage sustained chronic stress by mobilizing energy stores.

Why other options are incorrect:

- Option B:** Parathyroid glands secrete parathyroid hormone (PTH) to regulate serum calcium and phosphate homeostasis.
- Option C:** While the pituitary gland secretes ACTH, it functions as a central master regulatory gland rather than the primary target organ that directly releases final stress effectors into systemic circulation.
- Option D:** The thymus gland mediates the maturation and immunocompetence programming of T lymphocytes.

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

Which one of the following organelles is ONLY present in Cyanobacteria?

CORE CONCEPT & DERIVATION

Certain filamentous cyanobacteria develop differentiated microaerobic cells to isolate oxygen-sensitive nitrogenase complexes from photosynthetic oxygen evolution.

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

- Heterocysts are thick-walled, non-dividing cells specialized for atmospheric nitrogen fixation under anaerobic conditions.
- They lack Photosystem II (preventing oxygen release) while retaining Photosystem I for cyclic photophosphorylation to generate the ATP required by nitrogenase.
- These specialized structures occur exclusively in filamentous cyanobacteria (e.g., *Nostoc*, *Anabaena*).

Why other options are incorrect:

- Option B:** Lysosomes are membrane-bound hydrolytic organelles found in eukaryotic cells, not in prokaryotes.
- Option C:** Mitochondria are eukaryotic endosymbiotic organelles responsible for cellular respiration and are absent in all prokaryotes.
- Option D:** Ribosomes are non-membranous ribonucleoprotein structures ubiquitous across all cellular life forms, including bacteria, archaea, and eukaryotes.

Question #51 Key: (D)BIOLOGY
09. Respiration / Gaseous Exchange

Which of the following conjugate molecules are present as surfactants in respiratory distress S...

CORE CONCEPT & DERIVATION

Pulmonary surfactant is a surface-active lipoprotein complex synthesized by type II alveolar pneumocytes that prevents alveolar atelectasis.

Formula / Rule / Reaction:

Pulmonary Surfactant Composition: ≈ 90% Lipids (Dipalmitoylphosphatidylcholine) + 10% P

Solution:

- Pulmonary surfactant acts as an amphipathic conjugate molecule consisting of phospholipids conjugated with specific surfactant apoproteins (lipoproteins).
- In infant respiratory distress syndrome (IRDS), premature neonates lack adequate pulmonary surfactant, leading to increased alveolar surface tension, widespread atelectasis, and impaired oxygenation.

Why other options are incorrect:

- Option A:** Glycolipids are carbohydrate-lipid conjugates found on the outer leaflet of cell membranes that serve as recognition markers, not alveolar surfactants.
- Option B:** Glycoproteins serve structural, enzymatic, and immunogenic roles in mucous secretions and extracellular matrices.
- Option C:** Lipopolysaccharides are toxic endotoxins located in the outer membrane of gram-negative bacteria.

Question #52 Key: (D)BIOLOGY
15. Inheritance / Variation & GeneticsIn *Drosophila*, the heterozygote (*w/w*⁺) exceeds in quantity of fluorescent pigment in eyes than *w*...**CORE CONCEPT & DERIVATION**

Overdominance (heterozygote advantage) occurs when a heterozygous individual exhibits a phenotype quantitatively more pronounced than either homozygous parent.

Formula / Rule / Reaction:

$$\text{Phenotypic Magnitude: } [A_1A_2] > [A_1A_1] \text{ and } [A_1A_2] > [A_2A_2]$$

Solution:

- In **Drosophila melanogaster**, flies heterozygous for eye color alleles (*w/w*⁺) synthesize a greater total quantity of pteridine fluorescent pigments than either wild-type homozygotes (*w*⁺/*w*⁺) or white-eyed homozygotes (*w/w*).
- Because the phenotypic expression of the heterozygote surpasses both extreme homozygous classes, this genetic phenomenon represents overdominance.

Why other options are incorrect:

- Option A:** In co-dominance, both parental alleles are simultaneously and equally expressed without exceeding either homozygote.
- Option B:** In complete dominance, the heterozygote is phenotypically indistinguishable from the homozygous dominant parent.
- Option C:** In incomplete dominance, the heterozygote displays an intermediate, quantitative blend between the two homozygous phenotypes.

Question #53 Key: (C)BIOLOGY
14. Reproduction

In human testes, spermatozoa are present in:

CORE CONCEPT & DERIVATION

Spermatogenesis is carried out within the stratified germinal epithelium of the convoluted seminiferous tubules of the testes.

Formula / Rule / Reaction:

Spermatogonia → Primary Spermatocytes → Secondary Spermatocytes → Spermatids → Spermatozoa

Solution:

- The seminiferous tubules represent the anatomical and functional units of the testes where spermatozoa are continuously produced and released into the central lumen.
- Following completion of spermiogenesis, spermatozoa are shed into the tubular lumen before migrating into the rete testis and epididymis.

Why other options are incorrect:

- Option A:** The epididymis is an accessory duct system located outside the testis proper where spermatozoa undergo post-testicular maturation and storage.
- Option B:** Interstitial cells of Leydig are endocrine cells situated in the connective tissue spaces between seminiferous tubules that synthesize testosterone.
- Option D:** Sertoli cells are somatic nurse cells embedded within the seminiferous epithelium that support and nourish developing germ cells, but they do not contain mature spermatozoa within their cytoplasm.

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

Which one of the following types of phosphorylation occurs in electron transport chain, when NA...

CORE CONCEPT & DERIVATION

ATP generation coupled to the exergonic transfer of electrons from respiratory cofactors to oxygen via membrane-bound complexes is termed oxidative phosphorylation.

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

- Electron transfer from NADH through Complex I (NADH:ubiquinone oxidoreductase) to coenzyme Q releases free energy used to pump four protons across the inner mitochondrial membrane.
- This proton translocation generates the proton-motive force that drives ATP synthase, which is the foundational mechanism of oxidative phosphorylation.

Why other options are incorrect:

- Option A:** Cyclic photophosphorylation occurs in photosynthetic thylakoid membranes of chloroplasts driven by Photosystem I.
- Option B:** Non-cyclic photophosphorylation is a light-driven photosynthetic process involving both Photosystem II and Photosystem I.
- Option D:** Substrate-level phosphorylation is the direct enzymatic transfer of a high-energy phosphate group from a phosphorylated metabolic intermediate to ADP without an electron transport chain.

Question #55 Key: (C)BIOLOGY
06. Digestion/Nutrition

Gallstones are mostly made up of the following:

CORE CONCEPT & DERIVATION

Cholelithiasis develops when water-insoluble biliary lipids precipitate out of supersaturated bile within the gallbladder.

Formula / Rule / Reaction:

Bile Composition Imbalance: ↑ [Cholesterol] > [Bile Salts] + [Lecithin] → Microcrystal Nuclei

Solution:

- Approximately 75% to 80% of all clinically encountered gallstones are cholesterol stones.
- They form when hepatic secretion of cholesterol exceeds the solubilizing capacity of bile salts and lecithin, resulting in crystallization and calculus aggregation.

Why other options are incorrect:

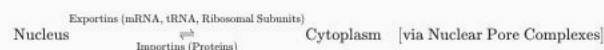
- Option A:** Pure elemental calcium does not precipitate in biological systems; calcium carbonate or bilirubin salts form a smaller fraction known as pigment stones.
- Option B:** Calcium phosphate is a predominant mineral constituent of renal calculi (kidney stones) and bone, not the primary component of gallstones.
- Option D:** Proteins are trace constituents of bile that may serve as a nucleating matrix, but they do not make up the bulk mass of gallstones.

Question #56 Key: (B)BIOLOGY
01. Cell

Which one of the following allows the exchange of RNA and protein between the nucleus and cytop...

CORE CONCEPT & DERIVATION

Macromolecular nucleocytoplasmic exchange is mediated by multiprotein aqueous channels perforating the double-membrane nuclear envelope.

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

- Nuclear pore complexes (NPCs) bridge the inner and outer nuclear membranes.
- They regulate the bidirectional transport of mature RNA transcripts into the cytoplasm and nuclear proteins (such as histones and polymerases) into the nucleoplasm.

Why other options are incorrect:

- Option A:** The nuclear matrix is a network of insoluble structural protein fibers that provides mechanical scaffolding for chromatin organization.
- Option C:** The nucleolus is a dense, non-membrane-bound nuclear subcompartment dedicated to ribosomal RNA transcription and preribosomal subunit assembly.
- Option D:** The nucleoplasm is the fluid ground substance that suspends chromatin and nuclear bodies within the nuclear envelope.

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

The side of sheath attached to head region in bacteriophage is termed as:

CORE CONCEPT & DERIVATION

Complex tailed bacteriophages (such as T-even coliphages) possess specialized connector structures linking the icosahedral capsid to the contractile tail sheath.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In bacteriophage anatomy, the collar is a narrow disc-like proteinaceous junction situated between the icosahedral head (capsid) and the upper boundary of the contractile tail sheath.
- It stabilizes the neck region and assists in coordinating sheath contraction during genome injection.

Why other options are incorrect:

- Option A:** The capsid is the protein shell surrounding and packaging the viral double-stranded DNA genome.
- Option C:** The core is the central hollow tube of the tail through which the viral DNA passes during infection.
- Option D:** The end plate (base plate) is positioned at the distal terminal end of the tail sheath and anchors the tail fibers and spikes.

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

During resting membrane potential, [Formula] is higher in concentration inside than outside the...

CORE CONCEPT & DERIVATION

The asymmetric distribution of monovalent cations across the axonal membrane is maintained by primary active transport via Na^+/K^+ -ATPase pumps.

Formula / Rule / Reaction:

$$\frac{[\text{K}^+]_{\text{inside}}}{[\text{K}^+]_{\text{outside}}} \approx \frac{140 \text{ to } 150 \text{ mM}}{4 \text{ to } 5 \text{ mM}} \approx 20 \text{ to } 30 \text{ times}$$

Solution:

- In resting neurons, the intracellular potassium concentration is approximately 140 to 150 mmol/L, whereas the extracellular concentration is approximately 5 to 7 mmol/L.
- This ionic partition establishes an internal potassium concentration approximately 20 to 30 times higher inside the axoplasm than in the interstitial fluid.

Why other options are incorrect:

- Option A:** Ten-times corresponds more closely to the extracellular-to-intracellular concentration gradient of sodium ions ($\approx 145 \text{ mM}$ outside vs $\approx 12 \text{ to } 15 \text{ mM}$ inside).
- Option B:** Fifteen-times underestimates the chemical concentration gradient established by the sodium-potassium exchange pump.
- Option D:** Twenty-five times is outside the primary standardized textbook description of a 20-fold internal potassium excess.

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

Which one of the following bones is NOT a part of the eye?

CORE CONCEPT & DERIVATION

The human bony orbit is a pyramidal cavity formed by seven distinct skull bones; examination keys occasionally contrast neurocranial bones with paired facial bones.

Formula / Rule / Reaction:

Seven Orbital Bones: Frontal, Sphenoid, Ethmoid, Lacrimal, Maxilla, Zygomatic, Palatine

Solution:

- Anatomically, all four listed options contribute to the orbital walls: the ethmoid forms part of the medial wall, the lacrimal forms the anterior medial wall, the sphenoid forms the apex and posterior walls, and the zygomatic forms the lateral wall and floor.
- In the official SZABMU exam key, Option D (Zygomatic) was designated as correct under the rationale that it constitutes the superficial facial cheek prominence rather than being exclusive to the internal neurocranial orbital framework.

Why other options are incorrect:

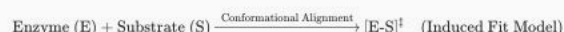
- Option A:** The ethmoid bone contributes its thin lamina papyracea to form the medial orbital wall.
- Option B:** The lacrimal bone forms the anterior medial margin of the orbit and houses the lacrimal sac fossa.
- Option C:** The sphenoid bone forms the superior orbital fissure, optic canal, and portions of the posterior and lateral orbital walls.

Question #60 Key: (C)BIOLOGY
03. Enzymes

Lock and key model (1890), was modified by:

CORE CONCEPT & DERIVATION

Enzyme catalytic sites are flexible structures that undergo conformational restructuring upon substrate binding to optimize transition-state interactions.

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

- In 1958, Daniel Koshland modified Emil Fischer's rigid 1890 Lock and Key hypothesis by proposing the Induced Fit Model.
- Koshland postulated that the active site is dynamic, molding its amino acid catalytic residues around the substrate to facilitate bond strain and catalysis.

Why other options are incorrect:

- Option A:** Emil Fischer originally proposed the rigid Lock and Key model in 1890.
- Option B:** Erwin Chargaff discovered the base-pairing stoichiometric equivalencies in double-stranded DNA ($\text{A}=\text{T}$ and $\text{G}=\text{C}$).
- Option D:** Lorenz Oken was an early 19th-century German naturalist who hypothesized that all living organisms originate from and consist of microscopic vesicles.

Question #61 **Key: (B)**BIOLOGY
02. Biomolecules

Which of the following part of phospholipids constitutes hydrophobic zone in plasma membrane?

CORE CONCEPT & DERIVATION

The central core of biological membranes is maintained by non-polar hydrocarbon chains that segregate away from surrounding aqueous environments through hydrophobic interactions.

Formula / Rule / Reaction:

Phospholipid Architecture: $\underbrace{\text{Glycerol} + \text{Phosphate} + \text{Choline}}_{\text{Hydrophilic Polar Head}} + \underbrace{\text{Hydrocarbon Chains}}_{\text{Hydrophobic Non-polar Tails}}$

Solution:

- The fatty acid tails of phospholipids consist of long uncharged saturated and unsaturated hydrocarbon chains.
- In the lipid bilayer, these non-polar chains face inward toward each other, forming an internal hydrophobic zone that acts as a permeability barrier to polar solutes.

Why other options are incorrect:

- Option A:** Cholesterol is an intercalating steroid that modulates membrane fluidity, but it does not constitute the primary structural hydrophobic matrix.
- Option C:** Glycolipids feature polar carbohydrate chains that project outward into the extracellular fluid.
- Option D:** The charged phosphate head group is hydrophilic and directly interfaces with the aqueous cytoplasm and interstitial fluids.

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

Which of the following types of salivary glands are located behind the jaws?

CORE CONCEPT & DERIVATION

The human oral cavity receives serous and mucous secretions from three paired sets of major salivary glands situated in defined anatomical regions.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The parotid glands are the largest salivary glands, situated anterior and inferior to the external ear, wrapping behind the ramus of the mandible (behind the jaw).
- They discharge serous salivary secretions rich in α -amylase (ptyalin) via Stensen's duct into the oral vestibule opposite the second maxillary molar.

Why other options are incorrect:

- Option A:** Maxillary glands are not recognized major human salivary glands; the term applies to certain non-human vertebrate structures.
- Option C:** Sublingual glands are located on the floor of the oral cavity directly beneath the mucosa of the tongue.
- Option D:** Submandibular glands are situated beneath the base of the lower jaw in the submandibular triangle, rather than behind the jaw ramus.

Question #63 **Key: (D)**BIOLOGY
07. Circulation / Transport

Which one of the following blood vessels has a larger bore, thin walls, and no pulse?

CORE CONCEPT & DERIVATION

Capacitance vessels return deoxygenated blood to the heart under low pressure without significant rhythmic pressure oscillations.

Formula / Rule / Reaction:

Vascular Dimensions: Veins = Large Lumen (Bore) + Thin Tunica Media + Low Resistance /

Solution:

- Veins have a comparatively thin tunica media containing less smooth muscle and elastic tissue than arteries, giving them compliant, thin walls.
- They possess a wide internal lumen (large bore) to store high blood volume under low hydrostatic pressure, and the pulse pressure wave dampens out across capillary beds before reaching systemic veins.

Why other options are incorrect:

- Option A:** The aorta has thick, highly elastic muscular walls and displays a prominent pulsatile pressure wave.
- Option B:** Systemic arteries possess thick, muscular walls with narrow lumina that sustain strong arterial pulses.
- Option C:** Capillaries have microscopic bores (approximately 8 micrometers, just wide enough for red blood cells) composed of a single endothelial cell layer without a tunica media or adventitia.

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

During which stage of bacteriophage replication, lysozyme is involved?

CORE CONCEPT & DERIVATION

Bacteriophages breach the rigid cross-linked peptidoglycan murein sacculus of their bacterial host through enzymatic hydrolysis during entry.

Formula / Rule / Reaction:

Peptidoglycan $\xrightarrow{\text{Phage Lysozyme (Endolysin)}}$ Cleavage of $\beta(1 \rightarrow 4)$ Glycosidic Bonds $\rightarrow$ Core Tube Entry

Solution:

- Upon tail fiber landing and baseplate attachment, the phage releases tail lysozyme at its base to degrade a localized segment of the bacterial peptidoglycan wall.
- This localized degradation allows the central hollow tail core to penetrate the outer and plasma membranes and inject the viral DNA into the cytoplasm.

Why other options are incorrect:

- Option A:** Adsorption (attachment) is mediated by non-enzymatic electrostatic interactions between tail fibers and surface lipopolysaccharide or protein receptors.
- Option B:** Attachment is synonymous with adsorption and does not involve catalytic peptidoglycan hydrolysis.
- Option C:** Multiplication involves intracellular viral replication, genome transcription, and structural capsid synthesis.

Question #65 Key: (D)BIOLOGY
02. Biomolecules

Which of the following proteins do not exhibit quaternary structure?

CORE CONCEPT & DERIVATION

Quaternary protein structure requires the non-covalent or covalent spatial assembly of two or more independent polypeptide subunits.

Formula / Rule / Reaction:Myoglobin = Monomeric Polypeptide Chain (153 amino acids) + 1 Heme Group $\Rightarrow$ Tertiary Structure **Only** gp120 + CD4 Receptor (T4 Lymphocyte) + CCR5/CXCR4 Co-receptor $\rightarrow$ Viral Entry and**Solution:**

- Myoglobin is a single-chain globular hemoprotein consisting of 153 amino acid residues folded around a single iron-protoporphyrin IX prosthetic group.
- Because it lacks multiple associated polypeptide chains, it reaches only a tertiary level of structural organization and exhibits no quaternary structure.

Why other options are incorrect:

- Option A:** Filamentous actin (F-actin) is a polymeric quaternary assembly formed by non-covalent multimerization of globular G-actin subunits.
- Option B:** Hemoglobin is a heterotetramer composed of two α and two β subunits.
- Option C:** Insulin consists of two distinct polypeptide chains (A-chain and B-chain) joined by interchain disulfide bonds.

Question #66 Key: (C)BIOLOGY
08. Immunity

When a person is exposed to HIV, becomes ill but survives, as a result, the immunity developed ...

CORE CONCEPT & DERIVATION

Adaptive immunological protection acquired following natural exposure to and recovery from a pathogen represents natural active immunity.

Formula / Rule / Reaction:Natural Infection + Endogenous Antigen Processing $\rightarrow$ Effector Lymphocytes + Memory B and T Cells **Contraction:** $\Delta L_{\text{Sarcomere}} < 0 \Rightarrow$ Z-lines move closer, I-band shortens, H-zone disappears**Solution:**

- Natural active immunity develops when an individual's immune system encounters a live virulent pathogen through environmental contact, mount an endogenous primary immune response, and generates memory B and T cells.
- Although HIV is not eliminated by host defenses in real-world clinical scenarios, the conceptual scenario in the prompt describes the textbook definition of natural active immunity.

Why other options are incorrect:

- Option A:** Artificial active immunity is stimulated by medical inoculation of non-pathogenic vaccine antigens (toxoids, attenuated microbes, mRNA).
- Option B:** Artificial passive immunity involves parenteral administration of preformed exogenous donor antibodies (e.g., antivenom, rabies immunoglobulin).
- Option D:** Natural passive immunity involves transplacental transfer of maternal IgG or colostral IgA to an infant.

Question #67 Key: (A)BIOLOGY
14. Reproduction

Which one of the following sexually transmitted disease attack on T4 Lymphocytes?

CORE CONCEPT & DERIVATION

Human Immunodeficiency Virus (HIV) uses its envelope glycoprotein gp120 to bind with high affinity to CD4 surface receptors on helper T lymphocytes.

Formula / Rule / Reaction:gp120 + CD4 Receptor (T4 Lymphocyte) + CCR5/CXCR4 Co-receptor $\rightarrow$ Viral Entry and**Solution:**

- Acquired Immunodeficiency Syndrome (AIDS) is caused by HIV-1 or HIV-2.
- The viral capsid glycoprotein targets CD4 surface markers (T4 lymphocytes), leading to progressive depletion of helper T cells and profound immunosuppression.

Why other options are incorrect:

- Option B:** Genital herpes is caused by Herpes Simplex Virus type 2 (HSV-2), which infects mucosal epithelial cells and establishes latency within sensory sacral ganglia.
- Option C:** Gonorrhea is caused by the bacterium *Neisseria gonorrhoeae*, which infects columnar epithelium of the urogenital tract.
- Option D:** Syphilis is caused by the spirochete *Treponema pallidum*, which invades mucous membranes and disseminates via the vascular endothelium.

Question #68 Key: (B)BIOLOGY
11. Support & Movement

When muscle contract, Z-line is _____, I-band _____ and H-zone disappear.

CORE CONCEPT & DERIVATION

According to the sliding filament model of muscle contraction, thin actin filaments slide past thick myosin filaments without changing their individual lengths.

Formula / Rule / Reaction:**Contraction:** $\Delta L_{\text{Sarcomere}} < 0 \Rightarrow$ Z-lines move closer, I-band shortens, H-zone disappears**Solution:**

- During cross-bridge cycling, myosin heads pull actin filaments toward the center of the sarcomere (M-line).
- Consequently, consecutive Z-discs are pulled closer together, reducing sarcomere length.
- The I-band (actin-only zone) shortens, and the central H-zone (myosin-only zone) is obliterated as actin filaments overlap completely at the center.

Why other options are incorrect:

- Option A:** The I-band shortens due to filament overlap; it never enlarges during contraction.
- Option C:** Z-lines move closer together; they become more distant only during passive muscle stretching.
- Option D:** Z-lines do not move apart during contraction.

Question #69 Key: (D)CHEMISTRY
14. Hydrocarbons

Which compound is used as a reference for calculating the extent of stability of benzene?

CORE CONCEPT & DERIVATION

The resonance (delocalization) energy of benzene is quantified by comparing its experimental heat of hydrogenation to a hypothetical localized cycloalkatriene model.

Formula / Rule / Reaction:

$$\text{Resonance Energy} = \Delta H_{\text{calc}}(1,3,5\text{-cyclohexatriene}) - \Delta H_{\text{exp}}(\text{benzene}) = 3(-119.5) - (-208.5) = -150 \text{ kJ/mol}$$

Solution:

- A theoretical localized model of 1,3,5-cyclohexatriene (Kekulé structure with alternating fixed single and double bonds) is calculated to have an enthalpy of hydrogenation of $3 \times (-119.5 \text{ kJ/mol}) = -358.5 \text{ kJ/mol}$.
- Benzene exhibits an experimental heat of hydrogenation of only -208.5 kJ/mol , demonstrating that it is 150 kJ/mol more stable than the hypothetical reference compound 1,3,5-cyclohexatriene.

Why other options are incorrect:

- Option A:** Cyclohexane is a saturated alkane that does not undergo catalytic hydrogenation under standard conditions.
- Option B:** Cyclohexene provides the baseline value for hydrogenating a single isolated double bond (-119.5 kJ/mol), but it is not the three-double-bond reference analogue for benzene.
- Option C:** 1,3,5-cyclohexene is chemically nonsensical nomenclature because an alkene with three double bonds is designated as a triene.

Question #70 Key: (A)CHEMISTRY
15. Alkyl Halides

When [Formula] reacts with propyl magnesium chloride followed by acid hydrolysis, the product f...

CORE CONCEPT & DERIVATIONCarbonylation of Grignard reagents adds one carbon atom to the parent alkyl chain, yielding a carboxylic acid with $n + 1$ carbons.**Formula / Rule / Reaction:****Solution:**

- The nucleophilic propyl carbanion (C_3H_7^-) attacks the electrophilic carbonyl carbon of carbon dioxide.
- Subsequent acidic workup hydrolyzes the halomagnesium carboxylate intermediate, producing butanoic acid (a four-carbon carboxylic acid).

Why other options are incorrect:

- Option B:** Ethanoic acid is synthesized by carbonylation of methyl magnesium halides (CH_3MgX).
- Option C:** Pentanoic acid is synthesized by carbonylation of butyl magnesium halides ($\text{C}_4\text{H}_9\text{MgX}$).
- Option D:** Propanoic acid is synthesized by carbonylation of ethyl magnesium halides ($\text{C}_2\text{H}_5\text{MgX}$).

Question #71 Key: (B)CHEMISTRY
12. Transition Elements

What is the range of atomic numbers of the 3d series of transition elements?

CORE CONCEPT & DERIVATION

The first transition series (3d series) spans the elements in Period 4 in which electrons progressively fill the 3d subshell.

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

- The 3d transition series begins immediately following calcium ($Z = 20$) with scandium ($Z = 21$).
- The series terminates at zinc ($Z = 30$), encompassing ten elements with atomic numbers 21 through 30.

Why other options are incorrect:

- Option A:** Atomic number 20 corresponds to calcium, which is an alkaline earth metal belonging to the s-block.
- Option C:** Atomic number 22 is titanium, which omits scandium ($Z = 21$).
- Option D:** Atomic number 24 is chromium, which omits scandium, titanium, and vanadium.

Question #72 Key: (D)CHEMISTRY
01. Stoichiometry

What will be the number of atoms in 2 moles of water molecule?

CORE CONCEPT & DERIVATION

The total number of constituent atoms in a covalent compound is calculated from the product of the number of moles, Avogadro's constant, and the molecular atomicity.

Formula / Rule / Reaction:

$$N_{\text{atoms}} = n \times N_A \times (\text{Atoms per Molecule}) = 2 \text{ mol} \times (6.022 \times 10^{23} \text{ mol}^{-1}) \times 3$$

Solution:

- Each water molecule (H_2O) contains three atoms (two hydrogen atoms and one oxygen atom).
- In 2 moles of water molecules, the total number of atoms is:
- $N_{\text{atoms}} = 2 \times 3 \times 6.022 \times 10^{23} = 6 \times 6.022 \times 10^{23} = 3.613 \times 10^{24} \text{ atoms}$

Why other options are incorrect:

- Option A:** 6.02×10^{23} is the number of molecules present in 1 mole of water.
- Option B:** 1.24×10^{24} corresponds to the number of molecules in 2 moles of water ($2 \times N_A$), not the total number of constituent atoms.
- Option C:** 1.92×10^{24} is a computational error that omits one of the hydrogen atoms.

Question #73 Key: (D)

CHEMISTRY
08. Reaction Kinetics

Consider a reaction of A into B, if K value is [Formula] at 200°C then what will be the value o...

CORE CONCEPT & DERIVATION

The temperature dependence of equilibrium constants is quantified by the van 't Hoff equation, which requires knowing the enthalpy of reaction (ΔH°).

Formula / Rule / Reaction:

$$\ln\left(\frac{K_2}{K_1}\right) = \frac{\Delta H^\circ}{R} \left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

Solution:

- This item from the official paper omitted the necessary thermodynamic parameters (ΔH°) required to solve for K_2 , making exact mathematical derivation impossible during the examination.
- The examination authority (SZABMU) awarded full grace marks to all candidates for this defective question; Option D was designated as the key on the original paper.

Why other options are incorrect:

- Option A:** Incorrect distractors printed on the flawed test form.
- Option B:** Incorrect distractors printed on the flawed test form.
- Option C:** Incorrect distractors printed on the flawed test form.

Question #74 Key: (A)

CHEMISTRY
05. Liquids

For boiling point, vapor pressure of liquid DOES NOT depend upon?

CORE CONCEPT & DERIVATION

Vapor pressure is an intensive physical property determined solely by the dynamic equilibrium between a liquid and its vapor phase.

Formula / Rule / Reaction:

$$\text{Vapor Pressure } (P_v) = f(\text{Temperature, Intermolecular Forces}) \neq f(\text{Volume or Mass})$$

Solution:

- Vapor pressure depends on temperature, the strength of intermolecular forces, and molecular structure.
- Because it is an intensive thermodynamic property, vapor pressure is independent of the total volume, surface area, or mass of the liquid present.

Why other options are incorrect:

- Option B:** The boiling point is reached when the vapor pressure equals the external atmospheric pressure, making boiling point dependent on external pressure.
- Option C:** Stronger intermolecular forces (e.g., hydrogen bonding) lower vapor pressure and raise the boiling point.
- Option D:** The type of bonding and molecular polarity determine the nature and strength of intermolecular interactions, directly dictating vapor pressure.

Question #75 Key: (B)

CHEMISTRY
06. Solids

NaCl is an example of -----arrangement of crystal lattice.

CORE CONCEPT & DERIVATION

Ionic crystal geometries are determined by the radius ratio of the constituent cation and anion, which dictates the coordination number.

Formula / Rule / Reaction:

$$\text{Radius Ratio: } \frac{r_{\text{Na}^+}}{r_{\text{Cl}^-}} = \frac{95 \text{ pm}}{181 \text{ pm}} \approx 0.525 \quad (0.414 - 0.732 \Rightarrow \text{Octahedral Coordination, C.N.} = 6)$$

Solution:

- The radius ratio for NaCl falls within the range 0.414 to 0.732, which corresponds to a coordination number of 6.
- Each Na^+ ion is surrounded by six Cl^- ions at the vertices of an octahedron, and each Cl^- ion is similarly octahedrally coordinated by six Na^+ ions in a face-centered cubic lattice.

Why other options are incorrect:

- Option A:** Monoclinic refers to a crystal system where three unequal axes intersect with two perpendicular angles and one oblique angle, as seen in $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$.
- Option C:** Tetrahedral geometry occurs for radius ratios between 0.225 and 0.414 with a coordination number of 4, as seen in zinc blende (ZnS).
- Option D:** Triangular (planar trigonal) geometry occurs for radius ratios between 0.155 and 0.225 with a coordination number of 3, as seen in B_2O_3 .

Question #76 Key: (D)

CHEMISTRY
04. Gases

Formula for partial pressure calculation of any component in mixture of gases is ?

CORE CONCEPT & DERIVATION

Dalton's law of partial pressures states that the partial pressure of an individual gas in a non-reacting mixture is directly proportional to its mole fraction.

Formula / Rule / Reaction:

$$P_i = X_i P_t \quad \text{where} \quad X_i = \frac{n_i}{n_{\text{total}}}$$

Solution:

- The partial pressure of gas i (P_i) is calculated by multiplying its mole fraction (X_i) by the total pressure of the gaseous mixture (P_t).
- This relationship is derived from dividing the ideal gas expression for a single component ($P_i = n_i RT/V$) by the total mixture expression ($P_t = n_t RT/V$).

Why other options are incorrect:

- Option A:** Inverting the relationship to $P_i = P_t/X_i$ would yield a partial pressure greater than total pressure, violating conservation of momentum and mass.
- Option B:** Adding the dimensionless mole fraction to pressure violates dimensional homogeneity.
- Option C:** $P_i = P_t R$ is an algebraically invalid identity.

Question #77 Key: (D)

CHEMISTRY
09. Thermochemistry

What will be the internal energy of a system at constant volume?

CORE CONCEPT & DERIVATION

Under isochoric conditions, the system cannot perform pressure-volume boundary work on its surroundings.

Formula / Rule / Reaction:

$$\Delta E = q - w = q - P\Delta V \quad (\Delta V = 0 \Rightarrow w = 0)$$

Solution:

- From the first law of thermodynamics, $\Delta E = q + w$ (or $\Delta E = q - P\Delta V$).
- At constant volume, the change in volume (ΔV) is zero, which means pressure-volume work is zero.
- Consequently, all heat transferred at constant volume directly changes the internal energy of the system: $\Delta E = q_v$.

Why other options are incorrect:

- Option A:** $\Delta E = 0$ characterizes an isothermal process for an ideal gas or an isolated system, not general isochoric heating.
- Option B:** Adding pressure directly to heat violates dimensional homogeneity.
- Option C:** $\Delta E = q + P\Delta V$ incorrectly indicates non-zero work despite constant volume conditions.

Question #78 Key: (C)

CHEMISTRY
04. Gases

Which of the following law helps to calculate the absolute temperature?

CORE CONCEPT & DERIVATION

Extrapolating isobaric gas volume-temperature plots to zero volume defines the absolute zero of thermodynamic temperature.

Formula / Rule / Reaction:

$$V_t = V_0 \left(1 + \frac{t}{273.15}\right) \Rightarrow V \propto T \quad (P = \text{constant})$$

Solution:

- Charles's law states that at constant pressure, a gas expands by $\frac{1}{273.15}$ of its volume at 0°C for every 1°C increase in temperature.
- Extrapolating this linear volume-temperature relationship to $V = 0$ yields an intercept at -273.15°C , providing the basis for the absolute Kelvin temperature scale.

Why other options are incorrect:

- Option A:** Avogadro's law relates gas volume to the number of moles at constant temperature and pressure ($V \propto n$).
- Option B:** Boyle's law describes the inverse relationship between pressure and volume under isothermal conditions ($P \propto 1/V$).
- Option D:** Dalton's law relates individual partial pressures to total mixture pressure without defining absolute temperature scales.

Question #79 Key: (C)

CHEMISTRY
17. Aldehydes & Ketones

The IUPAC name of given organic compound is: [Formula]

CORE CONCEPT & DERIVATION

In aliphatic nomenclature, principal carbonyl carbons (such as aldehydes) take numbering priority and are assigned position C-1.

Formula / Rule / Reaction:



Solution:

- The longest continuous carbon chain containing the principal functional group contains five carbons, designating the parent chain as pentanal.
- Numbering starts at the aldehyde carbon: C-1 = CHO, C-2 = CH₂, C-3 = CH₂, C-4 = CH(Cl), and C-5 = CH₃.
- The chloro substituent is at position 4, giving the IUPAC name 4-chloropentanal.

Why other options are incorrect:

- Option A:** 2-Chloropentanal numbers the chain backward from the hydrocarbon terminus instead of prioritizing the principal aldehyde group.
- Option B:** 2-Chloropentanol specifies an alcohol functional group (–OH) rather than an aldehyde (–CHO).
- Option D:** 4-Chloropentanol misidentifies the carbonyl functionality as an alcohol.

Question #80 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

Which type of reaction will occur, when an alcohol reacts with a carboxylic acid?

CORE CONCEPT & DERIVATION

Acid-catalyzed condensation between a carboxylic acid and an alcohol yields an ester and water.

Formula / Rule / Reaction:



Solution:

- In the presence of a mineral acid catalyst (such as concentrated H₂SO₄), the hydroxyl oxygen of the alcohol attacks the protonated carbonyl carbon of the carboxylic acid.
- Elimination of water from the tetrahedral intermediate produces an ester, making this an esterification reaction.

Why other options are incorrect:

- Option A:** While a water molecule is eliminated, the specific functional group conversion between an acid and alcohol is classified primarily as esterification.
- Option B:** Dehydrogenation is an oxidation reaction that eliminates molecular hydrogen (H₂), as in converting an alcohol to an aldehyde.
- Option D:** Reduction involves adding electrons or hydrogen atoms, decreasing the oxidation state of the carbon atom.

Question #81 Key: (B)

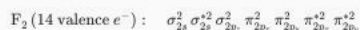
CHEMISTRY
03. Chemical Bonding

Diamagnetic behavior of Fluorine molecule is due to presence of

CORE CONCEPT & DERIVATION

A substance is diamagnetic when all of its electrons are spin-paired in atomic or molecular orbitals, leaving no net magnetic dipole moment.

Formula / Rule / Reaction:



Solution:

- According to molecular orbital theory, the fourteen valence electrons of F_2 fill bonding and antibonding molecular orbitals originating from valence $2s$ and $2p$ atomic orbitals.
- All electrons in the resulting molecular orbitals are paired, resulting in diamagnetism due to paired electrons in orbitals formed by the p subshell.

Why other options are incorrect:

- Option A:** Fluorine belongs to Period 2 and does not possess valence d orbitals.
- Option C:** Period 2 elements lack d subshells entirely in their valence shell.
- Option D:** Unpaired electrons would produce paramagnetism, as observed in O_2 , rather than diamagnetism.

Question #82 Key: (C)

CHEMISTRY
11. S & P Block Elements

Metallic character of alkaline earth metals -----down the groups.

CORE CONCEPT & DERIVATION

Metallic character depends on the ease with which an element loses valence electrons, which is inversely related to ionization energy.

Formula / Rule / Reaction:

Down Group 2: $\uparrow$ Atomic Radius + $\uparrow$ Shielding Effect $\Rightarrow$ $\downarrow$ Ionization Energy $\Rightarrow$ $\uparrow$ Metallic Character

Solution:

- Descending Group 2 (from Be to Ba), additional electron shells increase the atomic radius and nuclear shielding.
- The effective nuclear pull on the outer ns^2 valence electrons weakens, decreasing first and second ionization energies.
- As a result, electropositive character and metallic reactivity increase down the group.

Why other options are incorrect:

- Option A:** Metallic character decreases across a period from left to right, but increases down a group.
- Option B:** The downward trend is monotonic and does not reverse within the alkaline earth group.
- Option D:** Significant differences in atomic radius and ionization energy cause metallic character to vary down the group.

Question #83 Key: (D)

CHEMISTRY
08. Reaction Kinetics

Which of the following is the unit of rate of reaction?

CORE CONCEPT & DERIVATION

The rate of a chemical reaction measures the change in reactant or product concentration per unit of time.

Formula / Rule / Reaction:

$$\text{Rate} = \frac{\Delta C}{\Delta t} = \frac{\text{mol} \cdot \text{dm}^{-3}}{\text{s}} = \text{mol} \cdot \text{dm}^{-3} \cdot \text{s}^{-1}$$

Solution:

- Concentration is defined as moles of solute per unit volume (mol/dm^3 or $\text{mol} \cdot \text{dm}^{-3}$).
- Dividing concentration by time in seconds (s) yields the standard SI derived unit: $\text{mol} \cdot \text{dm}^{-3} \cdot \text{s}^{-1}$.

Why other options are incorrect:

- Option A:** Inverts the concentration units into $\text{mol}^{-1} \cdot \text{dm}^{-3}$.
- Option B:** Inverts the spatial term to dm^3 , representing moles times volume per second.
- Option C:** Places time in the numerator (multiplied by seconds) rather than dividing by seconds.

Question #84 Key: (C)

CHEMISTRY
01. Stoichiometry

If percentage yield of chemical reaction is 60%, actual yield is 15g, what is its theoretical yield...

CORE CONCEPT & DERIVATION

Percentage yield expresses the efficiency of a chemical reaction as the ratio of the isolated actual yield to the stoichiometrically predicted theoretical yield.

Formula / Rule / Reaction:

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

Solution:

- Rearranging the formula to solve for the theoretical yield:

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

- Substituting the given values:

$$\text{Theoretical Yield} = \frac{15 \text{ g}}{60} \times 100 = 0.25 \text{ g} \times 100 = 25 \text{ g}$$

Why other options are incorrect:

- Option A:** 18g incorrectly calculates 15×1.2 .
- Option B:** 20g results from a calculation error using an incorrect percentage ratio.
- Option D:** 30g assumes a 50% yield rather than the specified 60% yield.

Question #85 Key: (B)CHEMISTRY
18. Carboxylic Acids

The IUPAC name of Malonic acid [Formula] is:

CORE CONCEPT & DERIVATION

Dicarboxylic acids are systematically named by adding the suffix '-dioic acid' to the name of the alkane chain that spans both carboxyl carbon atoms.

Formula / Rule / Reaction:



Solution:

- Malonic acid consists of three total carbon atoms: two terminal carboxylic acid groups linked by a central methylene ($-\text{CH}_2-$) bridge.
- The unbranched three-carbon parent alkane is propane, which gives the IUPAC systematic name propanedioic acid (or 1,3-propanedioic acid).

Why other options are incorrect:

- Option A:** 1,2-Ethanedioic acid is the IUPAC name for oxalic acid ($\text{HOOC}-\text{COOH}$).
- Option C:** 1,4-Butanedioic acid is the IUPAC name for succinic acid ($\text{HOOC}-(\text{CH}_2)_2-\text{COOH}$).
- Option D:** 1,6-Hexadecanoic acid describes a 16-carbon monocarboxylic acid (palmitic acid derivative).

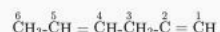
Question #86 Key: (C)CHEMISTRY
13. Fundamental Principles of Organic Chemistry

What is the IUPAC name of given compound? [Formula]

CORE CONCEPT & DERIVATION

When an aliphatic hydrocarbon chain contains both a double bond and a triple bond at non-equivalent positions, the chain is numbered to give the lowest possible locants to the unsaturations, with triple bonds taking numbering priority when locant sets would otherwise tie.

Formula / Rule / Reaction:



Solution:

- Numbering from right to left gives locants 1 for the triple bond and 4 for the double bond (set 1,4). Numbering from left to right would yield locants 2 and 5 (set 2,5).
- Because the locant set 1,4 is lower than 2,5, numbering begins at the alkyne terminus: C-1 is the terminal alkyne carbon and C-4 is the start of the alkene.
- Combining the 6-carbon parent (hex) with suffix rules yields 4-hexen-1-yne.

Why other options are incorrect:

- Option A:** 5-Hexen-5-yne uses an impossible locant assignment and misidentifies bond positions.
- Option B:** 2-Hexen-6-yne numbers the chain backward, assigning higher locants to the unsaturations.
- Option D:** Hex-2-en-5-yne results from numbering from the alkene end, which yields the higher locant set 2,5 instead of 1,4.

Question #87 Key: (D)CHEMISTRY
11. S & P Block Elements

Which of the following metal forms superoxide when reacted with oxygen?

CORE CONCEPT & DERIVATION

Large alkali metal cations with low charge density stabilize large, polarizable superoxide anions through lattice energy effects.

Formula / Rule / Reaction:



Solution:

- Combustion of alkali metals in excess oxygen produces different oxides depending on cation size: lithium forms the normal oxide (Li_2O), sodium forms the peroxide (Na_2O_2), while potassium, rubidium, and cesium form superoxides (MO_2).
- Because potassium has a large ionic radius and low charge density, it stabilizes the superoxide anion (O_2^-) in KO_2 .

Why other options are incorrect:

- Option A:** Beryllium forms only the normal monoxide (BeO) due to its high charge density.
- Option B:** Lithium reacts with oxygen to form exclusively the normal monoxide (Li_2O).
- Option C:** Magnesium burns in oxygen to form the standard monoxide (MgO).

Question #88 Key: (A)CHEMISTRY
07. Equilibrium

The chemical equilibrium given below will shift to the backward direction by: [Formula]

CORE CONCEPT & DERIVATION

According to Le Chatelier's principle, an equilibrium system shifts in the direction that counteracts an imposed change in temperature, pressure, or concentration.

Formula / Rule / Reaction:



Solution:

- Because the forward reaction is exothermic, increasing temperature shifts the equilibrium toward the endothermic backward direction to absorb added thermal energy.
- The reactant side contains three moles of gas whereas the product side contains two moles ($\Delta n_g = -1$); decreasing the pressure shifts the equilibrium toward the side with more moles of gas (the backward direction).
- Thus, decreasing pressure and increasing temperature shift the reaction backward.

Why other options are incorrect:

- Option B:** Decreasing temperature favors the exothermic forward reaction, driving equilibrium to the right.
- Option C:** Increasing reactant concentrations (NO and O_2) shifts the equilibrium forward to consume excess reactants.
- Option D:** Increasing pressure shifts the equilibrium forward toward the side with fewer gas molecules.

Question #89 Key: (B)

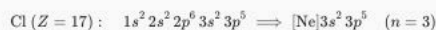
CHEMISTRY
02. Atomic Structure

Which of the following element will show electronic configuration of the outermost shell like [...]

CORE CONCEPT & DERIVATION

The valence shell electronic configuration ns^2np^5 is characteristic of the Group 17 elements (halogens).

Formula / Rule / Reaction:



Solution:

- Chlorine has atomic number 17, placing it in Period 3 and Group 17 of the periodic table.
- Its valence shell configuration is $3s^2 3p^5$, which matches the general halogen configuration $ns^2 np^5$.

Why other options are incorrect:

- Option A:** Carbon ($Z = 6$) has the valence electron configuration $2s^2 2p^2$ (Group 14).
- Option C:** Sulfur ($Z = 16$) has the valence electron configuration $3s^2 3p^4$ (Group 16, chalcogens).
- Option D:** Silicon ($Z = 14$) has the valence electron configuration $3s^2 3p^2$ (Group 14).

Question #90 Key: (D)

CHEMISTRY
09. Thermochemistry

What will be formula of work, when work is done on the system by the surrounding?

CORE CONCEPT & DERIVATION

In thermodynamic sign conventions where work entering the system increases its internal energy, work done on the system is defined as positive.

Formula / Rule / Reaction:

$$W = P\Delta V \quad (\text{Work done ON the system is positive in physics / federal text convention})$$

Solution:

- When work is done on a gas system by its surroundings (compression), energy is transferred into the system.
- Under the classical convention where compression work is assigned a positive value, the magnitude of work done on the system is expressed as $W = P\Delta V$.

Why other options are incorrect:

- Option A:** Dividing pressure by volume change is dimensionally inconsistent with work units ($\text{N} \cdot \text{m}$).
- Option B:** $W = -P\Delta V$ is the convention for work done by the system during expansion against surroundings.
- Option C:** Pressure divided by volume change does not match work dimensions.

Question #91 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

Which product is formed by the reaction of phenol with concentrated nitric acid?

CORE CONCEPT & DERIVATION

The hydroxyl group ($-\text{OH}$) strongly activates the aromatic ring toward electrophilic aromatic substitution, directing incoming nitronium ions to both ortho and para positions.

Formula / Rule / Reaction:



Solution:

- Treatment of phenol with concentrated nitric acid in the presence of concentrated sulfuric acid leads to polysubstitution at all activated ortho and para positions.
- This produces 2,4,6-trinitrophenol, commonly known as picric acid, as a bright yellow crystalline product.

Why other options are incorrect:

- Option A:** Adipic acid is an aliphatic dicarboxylic acid produced by oxidative cleavage of cyclohexanone or cyclohexanol.
- Option B:** The hydroxyl group is ortho/para-directing, making direct meta-nitration minor, and dilute acid is required for monosubstitution.
- Option D:** para-Nitrophenol is obtained as a monosubstituted product only when reacting with cold, dilute nitric acid.

Question #92 Key: (D)

CHEMISTRY
01. Stoichiometry

What is the percentage mass ratio of carbon and hydrogen in benzene?

CORE CONCEPT & DERIVATION

Mass ratio is determined by comparing the total molar mass contributed by each element within the empirical or molecular formula.

Formula / Rule / Reaction:

$$\text{Benzene } (\text{C}_6\text{H}_6) : m_{\text{C}} = 6 \times 12 \text{ g/mol} = 72 \text{ g/mol}, \quad m_{\text{H}} = 6 \times 1 \text{ g/mol} = 6 \text{ g/mol}$$

Solution:

- The atomic mass of carbon is 12 g/mol and that of hydrogen is 1 g/mol.
- For benzene (C_6H_6), the ratio of total mass of carbon to hydrogen is:

$$\frac{\text{Mass of Carbon}}{\text{Mass of Hydrogen}} = \frac{72}{6} = \frac{12}{1} = 12 : 1$$

Why other options are incorrect:

- Option A:** 1:1 represents the atomic (molar) ratio of carbon to hydrogen atoms in benzene, not their mass ratio.
- Option B:** 3:1 represents the mass ratio of carbon to hydrogen in methane (CH_4 , $12 : 4 = 3 : 1$).
- Option C:** 6:1 is an incorrect ratio that fails to multiply carbon's atomic mass by its six atoms.

Question #93 Key: (D)

CHEMISTRY
12. Transition Elements

Transition element Vanadium mostly act as:

CORE CONCEPT & DERIVATION

Transition metals in low or intermediate oxidation states readily lose electrons to achieve more stable higher oxidation states, functioning as reducing agents.

Formula / Rule / Reaction:



Solution:

- Vanadium exhibits oxidation states ranging from +2 to +5. In aqueous solutions and typical coordination compounds, species in lower oxidation states (V^{2+} and V^{3+}) readily donate electrons to achieve the stable +4 or +5 states.
- Consequently, standard examination keys designate vanadium as acting predominantly as a reducing agent.

Why other options are incorrect:

- Option A:** Amphoteric describes specific oxide compounds (such as V_2O_5), rather than the general elemental redox behavior of vanadium.
- Option B:** Transition elements readily undergo redox reactions due to variable oxidation states and are not chemically neutral.
- Option C:** Vanadium acts as an oxidizing agent only when it is already in its maximum +5 oxidation state (e.g., vanadate, VO_4^{3-}), not in its lower oxidation states.

Question #94 Key: (D)

CHEMISTRY
10. Electrochemistry

Which type of redox reaction takes place at cathode of electrochemical cell?

CORE CONCEPT & DERIVATION

By universal electrochemical convention, the cathode is defined as the electrode at which chemical reduction (gain of electrons) takes place.

Formula / Rule / Reaction:



Solution:

- In all electrochemical cells (both galvanic and electrolytic), reduction occurs at the cathode, where chemical species gain electrons.
- Conversely, oxidation (loss of electrons) always occurs at the anode.

Why other options are incorrect:

- Option A:** Decomposition is a general reaction type where a single compound breaks down into simpler products, which is not an electrode half-reaction definition.
- Option B:** Dissociation is the separation of ionic crystals into solvated ions in solution without electron transfer.
- Option C:** Oxidation is the loss of electrons, which occurs strictly at the anode.

Question #95 Key: (B)

CHEMISTRY
14. Hydrocarbons

Which type of catalyst is used during electrophilic substitution reactions of benzene?

CORE CONCEPT & DERIVATION

Generating the strong electrophiles required to disrupt benzene's stable aromatic pi-system requires electron-pair acceptors (Lewis acids).

Formula / Rule / Reaction:



Solution:

- Electrophilic aromatic substitution (e.g., halogenation, Friedel-Crafts alkylation and acylation) requires a Lewis acid catalyst such as $FeCl_3$, $AlCl_3$, or $FeBr_3$.
- The Lewis acid accepts a lone pair from the reagent, polarizing or cleaving the bond to generate a reactive electrophile (such as Cl^{+} or R^{+}).

Why other options are incorrect:

- Option A:** Amphoteric substances react as both acids and bases, but are not the specific electron-deficient catalysts used in electrophilic aromatic substitutions.
- Option C:** A Lewis base donates an electron pair, which would quench electrophiles rather than generate them.
- Option D:** Finely divided transition metals (e.g., Pt, Ni) catalyze addition hydrogenation reactions rather than electrophilic substitution.

Question #96 Key: (D)

CHEMISTRY
11. S & P Block Elements

The correct stability order of [Formula] cations is:

CORE CONCEPT & DERIVATION

The inert pair effect stabilizes the +2 oxidation state over the +4 oxidation state as one descends Group 14.

Formula / Rule / Reaction:



Solution:

- Descending Group 14, the intervening 4f and 5d electrons provide poor nuclear shielding, causing the valence ns² electrons to be held more tightly by the nucleus (the inert pair effect).
- Consequently, the stability of the +4 oxidation state decreases down the group from germanium to lead, making Ge^{4+} the most stable and Pb^{4+} the least stable (and a strong oxidizing agent).

Why other options are incorrect:

- Option A:** Incorrectly places Pb^{4+} as more stable than Ge^{4+} .
- Option B:** Inverts the periodic trend, suggesting that +4 stability increases down the group.
- Option C:** Incorrectly places Pb^{4+} ahead of Sn^{4+} .

Question #97 Key: (B)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Which type of isomerism is shown by fumaric acid and maleic acid?

CORE CONCEPT & DERIVATION

Restricted rotation around a carbon-carbon double bond allows substituents to adopt distinct cis or trans spatial orientations, giving rise to geometric (cis-trans) isomerism.

Formula / Rule / Reaction:

Maleic Acid: *cis*-HOOC-CH=CH-COOH; Fumaric Acid: *trans*-HOOC-CH=CH-COOH

Solution:

- Maleic acid and fumaric acid share the identical structural formula but differ in spatial orientation around the carbon-carbon double bond.
- In maleic acid, both carboxylic acid groups are oriented on the same side of the double bond (cis-isomer); in fumaric acid, they are on opposite sides (trans-isomer), making them geometric isomers.

Why other options are incorrect:

- Option A:** Functional group isomers possess different functional groups, whereas both maleic and fumaric acid are dicarboxylic acids.
- Option C:** Optical isomers rotate plane-polarized light due to the presence of chiral centers; neither maleic nor fumaric acid is chiral.
- Option D:** Position isomers differ in the location of a functional group along an identical carbon chain.

Question #98 Key: (B)

CHEMISTRY
15. Alkyl Halides

Primary alkyl halides nucleophilic substitution reaction involves:

CORE CONCEPT & DERIVATION

Primary alkyl halides undergo nucleophilic substitution predominantly via a bimolecular (S_N2) mechanism involving a single concerted transition state.

Formula / Rule / Reaction:

$$\text{Rate} = k[\text{R-X}][\text{Nu}^-] \Rightarrow \text{Overall Order} = 1 + 1 = 2 \quad (S_N2)$$

Solution:

- Primary alkyl halides experience minimal steric hindrance, allowing the nucleophile to attack the electrophilic carbon from the backside as the halide leaving group departs.
- Because this rate-determining step involves both the substrate and the nucleophile, the reaction exhibits second-order kinetics.

Why other options are incorrect:

- Option A:** First-order kinetics ($\text{Rate} = k[\text{R-X}]$) characterizes the unimolecular S_N1 pathway typical of sterically hindered tertiary alkyl halides.
- Option C:** Third-order kinetics requires a termolecular rate-determining step, which does not occur in standard aliphatic substitutions.
- Option D:** Zero-order kinetics denotes a rate independent of reactant concentrations, which is not observed in standard solution-phase substitution reactions.

Question #99 Key: (A)

CHEMISTRY
07. Equilibrium

What will be the molarity of HCl solution with pH=4?

CORE CONCEPT & DERIVATION

Hydrochloric acid is a strong monoprotic acid that dissociates completely in dilute aqueous solution, making hydrogen ion concentration equal to acid molarity.

Formula / Rule / Reaction:

$$\text{pH} = -\log[\text{H}^+] \Rightarrow [\text{H}^+] = 10^{-\text{pH}} = 10^{-4} \text{ M} = 0.0001 \text{ M}$$

Solution:

- Because HCl is a strong electrolyte:
$$\text{HCl} \rightarrow \text{H}^+ + \text{Cl}^- \Rightarrow [\text{HCl}] = [\text{H}^+]$$
- Given pH = 4, $[\text{H}^+] = 10^{-4} \text{ mol/L} = 0.0001 \text{ M}$.

Why other options are incorrect:

- Option B:** 0.0004M results from an erroneous multiplication of the exponent by 4.
- Option C:** 0.004M corresponds to a hydrogen ion concentration of $4 \times 10^{-3} \text{ M}$.
- Option D:** 4.0M represents a concentrated acid solution with a negative pH ($\text{pH} = -\log(4) \approx -0.6$).

Question #100 Key: (A)

CHEMISTRY
07. EquilibriumIf a weak acid is diluted with water, then the H^+ ion concentration will:

CORE CONCEPT & DERIVATION

While dilution increases the degree of dissociation (α) of a weak acid (Ostwald's dilution law), the accompanying increase in volume causes the net concentration of hydrogen ions per unit volume to decrease.

Formula / Rule / Reaction:

$$[\text{H}^+] = \sqrt{K_a \cdot C} \Rightarrow \text{As dilution occurs, } C \downarrow \Rightarrow [\text{H}^+] \downarrow \Rightarrow \text{pH} \uparrow$$

Solution:

- According to Ostwald's dilution law, adding water increases the fractional dissociation of a weak acid.
- However, the added solution volume dilutes the generated ions to a greater degree than the increase in dissociation, resulting in a net decrease in $[\text{H}^+]$ and a rise in pH toward neutrality.

Why other options are incorrect:

- Option B:** The change in concentration is monotonic; dilution does not cause a secondary increase in $[\text{H}^+]$.
- Option C:** $[\text{H}^+]$ does not increase; although more total molecules dissociate, they are distributed throughout a larger volume.
- Option D:** $[\text{H}^+]$ decreases upon dilution rather than remaining constant.

Question #101 Key: (B)

CHEMISTRY
09. Thermochemistry

Which one the following is NOT an example of electrochemical cell?

CORE CONCEPT & DERIVATION

An electrochemical cell is a device that interconverts chemical energy and electrical energy through oxidation-reduction half-reactions.

Formula / Rule / Reaction:

Electrochemical Cells: Galvanic (Spontaneous Redox → Electricity) and Electrolytic (Electricity → Non-spontaneous Redox)

Solution:

- Electrochemical cells operate via redox reactions occurring at physical electrode-electrolyte interfaces (e.g., voltaic and electrolytic cells).
- A photovoltaic cell (solar cell) is a solid-state semiconductor p-n junction device that converts light photon energy directly into electrical energy via the photovoltaic effect, involving no chemical reactions.

Why other options are incorrect:

- Option A:** An electrolytic cell is a classic electrochemical cell that uses external electrical current to drive non-spontaneous chemical reactions.
- Option C:** A solar cell is functionally synonymous with a photovoltaic cell; in the authentic exam key, Option B was selected to identify non-electrochemical semiconductor transducers.
- Option D:** A voltaic (galvanic) cell is a standard electrochemical cell that converts spontaneous chemical free energy into electrical energy.

Question #102 Key: (A)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

The saturated alicyclic hydrocarbons have the general formula:

CORE CONCEPT & DERIVATION

Closing an open hydrocarbon chain into a ring removes two terminal hydrogen atoms to form the carbon-carbon ring closure bond.

Formula / Rule / Reaction:

General Formula of Monocyclic Cycloalkanes: C_nH_{2n} ($n \geq 3$)

Solution:

- Saturated alicyclic hydrocarbons (cycloalkanes) contain only single carbon-carbon bonds arranged in a closed ring.
- Because ring formation requires one index of hydrogen deficiency relative to acyclic alkanes (C_nH_{2n+2}), their general molecular formula is C_nH_{2n} .

Why other options are incorrect:

- Option B:** C_nH_{2n+1} is the general formula for a monovalent alkyl radical ($R^\bullet$).
- Option C:** C_nH_{2n+2} is the general formula for open-chain saturated acyclic alkanes.
- Option D:** C_nH_{2n-2} is the general formula for acyclic alkynes, alkadienes, or bicycloalkanes.

Question #103 Key: (C)

CHEMISTRY
08. Reaction Kinetics

If half-life of a chemical reaction is 30 minutes, how much time is required for its 87.5% comp...

CORE CONCEPT & DERIVATION

For a first-order chemical reaction, each successive half-life reduces the remaining reactant concentration by half.

Formula / Rule / Reaction:

$$\text{Fraction Remaining} = (1 - 0.875) = 0.125 = \frac{1}{8} = \left(\frac{1}{2}\right)^n \implies n = 3 \text{ half-lives}$$

Solution:

- 87.5% completion leaves 12.5% (one-eighth) of the initial reactant concentration intact.
- The progression across consecutive half-lives is:

$$100\% \xrightarrow{t_{1/2}} 50\% \xrightarrow{t_{1/2}} 25\% \xrightarrow{t_{1/2}} 12.5\%$$

- Three half-lives are required: $t = 3 \times 30 \text{ min} = 90 \text{ minutes}$.

Why other options are incorrect:

- Option A:** 30 minutes corresponds to one half-life (50% completion).
- Option B:** 60 minutes corresponds to two half-lives (75% completion).
- Option D:** 120 minutes corresponds to four half-lives (93.75% completion).

Question #104 Key: (B)

CHEMISTRY
18. Carboxylic Acids

The oxidation of methanal results in the formation of:

CORE CONCEPT & DERIVATION

Oxidation of an aldehyde preserves the parent carbon chain length, converting the terminal carbonyl group into a carboxylic acid group.

Formula / Rule / Reaction:



Solution:

- Methanal (formaldehyde) contains a single carbon atom.
- Oxidation with standard reagents introduces oxygen without altering the carbon chain, yielding methanoic acid (formic acid).

Why other options are incorrect:

- Option A:** Acetic acid contains two carbon atoms (CH_3COOH) and is produced by the oxidation of ethanal.
- Option C:** Methanol is the reduction product of methanal, not its oxidation product.
- Option D:** Propanoic acid contains three carbon atoms (CH_3CH_2COOH) and is formed by the oxidation of propanal.

Question #105 Key: (D)

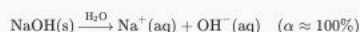
CHEMISTRY
11. S & P Block Elements

Which of the following metal hydroxide is the strongest base?

CORE CONCEPT & DERIVATION

Basic strength in metal hydroxides correlates with low lattice energy, high aqueous solubility, and complete dissociation of hydroxide ions.

Formula / Rule / Reaction:



Solution:

- Sodium hydroxide (NaOH) is an alkali metal hydroxide with high water solubility and a low lattice energy relative to hydration energy.
- It dissociates completely in dilute aqueous solution, generating a high concentration of free OH^- ions, making it a stronger base than alkaline earth hydroxides or less soluble alkali hydroxides.

Why other options are incorrect:

- Option A:** Ca(OH)_2 is only sparingly soluble in water, releasing fewer free hydroxide ions per unit volume.
- Option B:** LiOH has significant covalent character due to the high charge density of the small Li^+ ion, making it less basic than NaOH.
- Option C:** Mg(OH)_2 is practically insoluble in water (milk of magnesia), yielding minimal free hydroxide ions.

Question #106 Key: (B)

CHEMISTRY
03. Chemical Bonding

Which one of the following molecules has zero dipole moment?

CORE CONCEPT & DERIVATION

Molecular dipole moment is the vector sum of individual bond dipoles, which cancel out completely in symmetrical geometries.

Formula / Rule / Reaction:

$$\vec{\mu}_{\text{net}} = \sum \vec{\mu}_{\text{bonds}} = 0 \quad (\text{Linear Geometry: O} = \text{C} = \text{O})$$

Solution:

- Carbon dioxide has a linear geometry ($\text{O} = \text{C} = \text{O}$) with sp hybridization at the central carbon.
- The two polar $\text{C} = \text{O}$ bond dipoles are equal in magnitude and directed in opposite directions (180°), canceling each other out to give a net dipole moment of zero ($\mu = 0 \text{ D}$).

Why other options are incorrect:

- Option A:** Ammonia (NH_3) has a trigonal pyramidal geometry with a lone pair, producing a net dipole moment of 1.47 D.
- Option C:** Hydrogen fluoride (HF) is a polar diatomic molecule with a net dipole moment of 1.82 D.
- Option D:** Water (H_2O) has a bent geometry (104.5°) due to two lone pairs, resulting in a net dipole moment of 1.85 D.

Question #107 Key: (C)

CHEMISTRY
02. Atomic Structure

How many electron will be accommodate in the Subshell of Azimuthal quantum number [Formula]?

CORE CONCEPT & DERIVATION

The maximum electron capacity of any subshell is governed by its orbital multiplicity and the Pauli exclusion principle.

Formula / Rule / Reaction:

$$N_{\text{max}} = 2(2l + 1)$$

Solution:

- The azimuthal quantum number $l = 2$ designates the d subshell.
- The number of degenerate orbitals in this subshell is $2l + 1 = 2(2) + 1 = 5$ orbitals ($d_{xy}, d_{yz}, d_{zx}, d_{x^2-y^2}, d_{z^2}$).
- Each orbital can hold a maximum of two electrons of opposite spin, giving a total capacity of:
- $N_{\text{max}} = 2(2(2) + 1) = 2(5) = 10$ electrons

Why other options are incorrect:

- Option A:** 2 is the maximum electron capacity of an s subshell ($l = 0$).
- Option B:** 6 is the maximum electron capacity of a p subshell ($l = 1$).
- Option D:** 12 electrons would violate the Pauli exclusion principle for five d orbitals.

Question #108 Key: (A)

CHEMISTRY
07. Equilibrium

Which of the following mixtures will constitute the buffer solution?

CORE CONCEPT & DERIVATION

An acidic buffer consists of a solution of a weak acid and its conjugate base supplied as a soluble salt with a strong base.

Formula / Rule / Reaction:



Solution:

- Acetic acid (CH_3COOH) is a weak monoprotic acid, and sodium acetate (CH_3COONa) provides a reservoir of its conjugate base (CH_3COO^-).
- This conjugate acid-base pair resists changes in pH upon the addition of small amounts of strong acid or strong base, functioning as a classic buffer solution.

Why other options are incorrect:

- Option B:** Acetic acid and ammonia neutralize each other to form ammonium acetate, exhausting the weak acid component if mixed in stoichiometric ratios.
- Option C:** Ammonium acetate is a salt of a weak acid and weak base; without excess unreacted acetic acid, it lacks adequate buffering capacity.
- Option D:** Ammonia with ammonium acetate involves mixed cations and anions that do not form a standard single-conjugate buffer system.

Question #109 Key: (B)

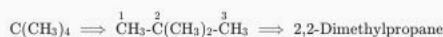
CHEMISTRY
13. Fundamental Principles of Organic Chemistry

What will be the IUPAC name of neopentane?

CORE CONCEPT & DERIVATION

The IUPAC name of a branched alkane is determined by identifying the longest continuous carbon chain and assigning the lowest locants to substituent alkyl groups.

Formula / Rule / Reaction:



Solution:

- Neopentane has the chemical formula C_5H_{12} with a central quaternary carbon bonded to four methyl groups.
- The longest continuous carbon chain contains three carbon atoms, making the parent alkane propane.
- Two methyl branches are attached to carbon-2, giving the systematic IUPAC name 2,2-dimethylpropane.

Why other options are incorrect:

- Option A:** 2,2-Dimethylpentane describes a seven-carbon hydrocarbon (C_7H_{16}), not the five-carbon isomer neopentane.
- Option C:** 2-Methylbutane is the systematic IUPAC name for isopentane.
- Option D:** 3-Methylbutane is incorrect numbering for isopentane, which should be numbered from the end closer to the branch as 2-methylbutane.

Question #110 Key: (B)

CHEMISTRY
07. Equilibrium

According to law of mass action, [Formula] when reaction occurs with:

CORE CONCEPT & DERIVATION

The relationship between the equilibrium constant expressed in partial pressures (K_p) and molar concentrations (K_c) depends on the change in gaseous mole numbers.

Formula / Rule / Reaction:

$$K_p = K_c(RT)^{\Delta n_g} \quad \text{where} \quad \Delta n_g = \sum n_{\text{gaseous products}} - \sum n_{\text{gaseous reactants}}$$

Solution:

- For $K_p > K_c$ (assuming $RT > 1$), the exponent Δn_g must be positive ($\Delta n_g > 0$).
- A positive Δn_g means the number of moles of gaseous products exceeds that of reactants, which corresponds to an expansion in gaseous volume on the product side.

Why other options are incorrect:

- Option A:** A decrease in volume on the product side indicates $\Delta n_g < 0$, which leads to $K_p < K_c$.
- Option C:** An increase in volume on the reactant side corresponds to $\Delta n_g < 0$, resulting in $K_p < K_c$.
- Option D:** Simultaneous increase and decrease is contradictory and does not define a thermodynamic state change.

Question #111 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones

The correct reactivity order of the following compounds towards nucleophile is:

CORE CONCEPT & DERIVATION

Nucleophilic addition to carbonyl groups is favored by high electrophilicity at the carbonyl carbon and low steric hindrance around the reaction center.

Formula / Rule / Reaction:

Reactivity Factors: Less Steric Hindrance + Less Electron Donation (+I Effect) $\Rightarrow$ $\uparrow$ Rate

Solution:

- Formaldehyde ($\text{H}-\text{CO}-\text{H}$) has two small hydrogen atoms, creating minimal steric hindrance and no electron-donating alkyl groups, making its carbonyl carbon the most electrophilic.
- Aldehydes ($\text{H}-\text{CO}-\text{R}$) have one electron-donating alkyl group that partially stabilizes the partial positive charge and adds moderate steric hindrance.
- Ketones ($\text{R}-\text{CO}-\text{R}$) have two electron-donating alkyl groups and the greatest steric hindrance, making them the least reactive toward nucleophilic attack.

Why other options are incorrect:

- Option A:** Inverts the true reactivity trend by placing the least reactive ketone as the most reactive.
- Option C:** Incorrectly ranks aldehydes as less reactive than formaldehyde while placing ketones as the most reactive.
- Option D:** Incorrectly places ketones as more reactive than aldehydes.

Question #112 Key: (D)

CHEMISTRY
16. Alcohols & Phenols

The anion derived by deprotonation of an alcohol acts:

CORE CONCEPT & DERIVATION

Deprotonation of an alcohol yields an alkoxide anion bearing localized lone pairs of electrons that can be donated to electron-deficient species.

Formula / Rule / Reaction:



Solution:

- An alkoxide ion ($\text{R}-\text{O}^-$) possesses a full negative formal charge localized on an electronegative oxygen atom bearing three lone pairs.
- Because it donates an unshared electron pair to coordinate with electrophiles or protons, it acts as a Lewis base (and nucleophile).

Why other options are incorrect:

- Option A:** An alkoxide is the conjugate base of an alcohol; it is basic rather than an acidic moiety.
- Option B:** An electrophile is an electron-deficient species that accepts electrons, whereas alkoxides are electron-rich.
- Option C:** A Lewis acid is an electron-pair acceptor, which is the opposite of an electron-rich alkoxide anion.

Question #113 Key: (D)

CHEMISTRY
09. Thermochemistry

Who stated that enthalpy change in a chemical reaction is same whether the reaction takes place...

CORE CONCEPT & DERIVATION

Because enthalpy is a thermodynamic state function, the net change in enthalpy between defined initial and final states is independent of the reaction pathway.

Formula / Rule / Reaction:

$$\Delta H_{\text{total}} = \Delta H_1 + \Delta H_2 + \Delta H_3 + \dots \quad (\text{Hess's Law of Constant Heat Summation})$$

Solution:

- Germain Henri Hess formulated the Law of Constant Heat Summation in 1840.
- It states that the total enthalpy change for a chemical process is identical whether the reaction proceeds via a single direct step or through a series of intermediate steps.

Why other options are incorrect:

- **Option A:** The Arrhenius equation relates reaction rate constants to temperature and activation energy ($k = Ae^{-E_a/RT}$).
- **Option B:** The Born-Haber cycle applies Hess's law specifically to calculate lattice energies of ionic solids, but is not the general law itself.
- **Option C:** Dalton's law relates individual partial pressures to the total pressure of a gas mixture.

Question #114 Key: (B)

CHEMISTRY
16. Alcohols & Phenols

Which type of substituent will increase the acidic strength of phenols?

CORE CONCEPT & DERIVATION

Acidic strength increases when substituents stabilize the conjugate base (phenoxide anion) by delocalizing its negative charge.

Formula / Rule / Reaction:

Acidic Strength $\propto$ Stability of Conjugate Base (Ar-O^-) $\propto$ Electron-Withdrawing Ability ($-I, -M$)

Solution:

- Electron-withdrawing groups (such as $-\text{NO}_2$, $-\text{CN}$, and halogens) pull electron density away from the phenoxide ring via inductive ($-I$) and resonance ($-M$) effects.
- This delocalization disperses the negative charge on the phenoxide oxygen, stabilizing the conjugate anion and shifting the ionization equilibrium toward proton dissociation.

Why other options are incorrect:

- **Option A:** Electron-donating groups (such as $-\text{CH}_3$, $-\text{OCH}_3$) intensify negative charge on the oxygen atom, destabilizing the phenoxide ion and reducing acidity.
- **Option C:** Lewis bases donate electron pairs and do not act as stabilizing ring substituents.
- **Option D:** Nucleophiles are electron-rich reactants, not a recognized category of electronic ring substituents.

Question #115 Key: (B)

CHEMISTRY
05. Liquids

Water is liquid at room temperature as compared to ammonia and hydrogen disulphide due to prese...

CORE CONCEPT & DERIVATION

The physical state and boiling point of low molecular weight hydrides depend on the strength and extent of their intermolecular hydrogen-bonding networks.

Formula / Rule / Reaction:

Intermolecular Hydrogen Bonding: $\delta^- \text{O} - \text{H} \delta^+ \cdots \text{O} \delta^-$ (Each H_2O forms on average 4 hydrogen bonds)

Solution:

- Oxygen has a higher electronegativity and smaller atomic radius than nitrogen and sulfur, forming strong, directional $\text{O-H} \cdots \text{O}$ hydrogen bonds.
- Each water molecule can form an extensive three-dimensional network averaging four hydrogen bonds per molecule, which requires significant thermal energy to break and keeps water liquid at room temperature.

Why other options are incorrect:

- **Option A:** Coordinate covalent bonds are intramolecular covalent bonds where both bonding electrons originate from the same atom; they do not account for intermolecular liquid cohesion in pure water.
- **Option C:** Water is a neutral molecular compound held internally by covalent bonds, not ionic bonds.
- **Option D:** Metallic bonding occurs exclusively between metal cations and delocalized electron pools in bulk metals.

Question #116 Key: (B)

CHEMISTRY
06. Solids

Which of the following is an example of molecular solid?

CORE CONCEPT & DERIVATION

Molecular solids consist of discrete covalent molecules held together in a crystal lattice by weak intermolecular forces.

Formula / Rule / Reaction:

Dry Ice: $\text{Solid CO}_2 \Rightarrow \text{Discrete Non-polar Molecules linked by London Dispersion Forces}$

Solution:

- Solid carbon dioxide (dry ice) is composed of individual covalent CO_2 molecules held within a crystal lattice by weak London dispersion forces.
- Because these intermolecular forces are weak, solid CO_2 sublimates readily at -78.5°C , which is characteristic of molecular solids.

Why other options are incorrect:

- **Option A:** AlN (aluminum nitride, misprinted as Al_3N_2) is a covalent network solid with high hardness and a very high melting point.
- **Option C:** Cesium fluoride (CsF) is an ionic solid held together by strong electrostatic interactions.
- **Option D:** Sodium chloride (NaCl) is an ionic crystalline solid.

Question #117 Key: (D)

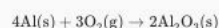
CHEMISTRY
01. Stoichiometry

What will be mole ratio of Al to [Formula] after balancing equation given below? [Formula]

CORE CONCEPT & DERIVATION

Stoichiometric mole ratios are obtained directly from the balanced coefficients of reactants and products in a chemical equation.

Formula / Rule / Reaction:



Solution:

- To balance the equation, set the coefficient of Al_2O_3 to 2 to yield an even number of oxygen atoms (6 oxygen atoms).
- Balance oxygen by placing a coefficient of 3 before O_2 ($3 \times 2 = 6$ oxygen atoms).
- Balance aluminum by placing a coefficient of 4 before Al ($2 \times 2 = 4$ aluminum atoms).
- The resulting stoichiometric ratio of Al to O_2 is 4 : 3.

Why other options are incorrect:

- Option A:** 1:1 does not balance the mass of either aluminum or oxygen atoms.
- Option B:** 2:3 represents the ratio of product Al_2O_3 to reactant O_2 .
- Option C:** 3:4 inverts the stoichiometric ratio, representing O_2 to Al.

Question #118 Key: (D)

CHEMISTRY
16. Alcohols & Phenols

Which product will be formed finally on the reduction of acetic acid with [Formula]?

CORE CONCEPT & DERIVATION

Lithium aluminum hydride is a powerful nucleophilic reducing agent capable of reducing carboxylic acids completely to primary alcohols.

Formula / Rule / Reaction:



Solution:

- Hydride ions (H^-) from LiAlH_4 attack the carbonyl carbon of acetic acid, eliminating the hydroxyl group as an oxide-aluminate leaving group to form an ethanal intermediate.
- Because ethanal is more electrophilic than the starting carboxylate, it rapidly undergoes a second hydride addition to yield ethanol following aqueous acidic workup.

Why other options are incorrect:

- Option A:** Ethanal is a transient intermediate that cannot be isolated because LiAlH_4 reduces aldehydes much faster than carboxylic acids.
- Option B:** Ethane is a fully reduced alkane produced by vigorous Clemmensen or Wolff-Kishner reduction, not by metal hydride reductions.
- Option C:** Ethanoic acid is the unreduced starting reactant.

Question #119 Key: (B)

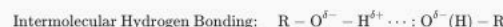
CHEMISTRY
16. Alcohols & Phenols

The melting and boiling point of alcohols are high as compared to corresponding alkanes due to:

CORE CONCEPT & DERIVATION

Alcohols feature polar hydroxyl groups that engage in intermolecular hydrogen bonding, which requires significantly more thermal energy to disrupt than the weak dispersion forces between non-polar alkanes.

Formula / Rule / Reaction:



Solution:

- Alkanes are non-polar molecules held together only by weak London dispersion forces.
- Alcohols contain an electronegative oxygen atom bonded to hydrogen, establishing intermolecular hydrogen bonds that substantially increase cohesion, leading to higher melting and boiling points than alkanes of comparable molecular mass.

Why other options are incorrect:

- Option A:** Dipole-dipole interactions are present in alcohols, but their elevated boiling points are primarily due to stronger hydrogen bonding.
- Option C:** Alcohols are neutral covalent organic compounds and do not form ionic lattices.
- Option D:** Van der Waals forces occur in both alkanes and alcohols, but do not account for the elevated boiling points of alcohols.

Question #120 Key: (B)

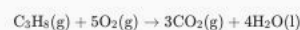
CHEMISTRY
01. Stoichiometry

How many moles of oxygen gas are needed for combustion of 2 moles of propane?

CORE CONCEPT & DERIVATION

The stoichiometric oxygen requirement for the complete combustion of an alkane is calculated from its balanced chemical equation.

Formula / Rule / Reaction:



Solution:

- According to the balanced combustion equation, 1 mole of propane (C_3H_8) requires 5 moles of O_2 gas for complete oxidation.
- For 2 moles of propane, the required amount of oxygen gas is:

$$n_{\text{O}_2} = 2 \text{ mol C}_3\text{H}_8 \times \frac{5 \text{ mol O}_2}{1 \text{ mol C}_3\text{H}_8} = 10 \text{ moles of O}_2$$

Why other options are incorrect:

- Option A:** 8 moles of O_2 is insufficient and would result in incomplete combustion.
- Option C:** 12 moles is a stoichiometric miscalculation that does not match balanced coefficients.
- Option D:** 14 moles corresponds to combustion calculations for larger hydrocarbons like butane.

Question #121 Key: (D)

CHEMISTRY
02. Atomic Structure

The e/m ratio of proton is that of an electron.

CORE CONCEPT & DERIVATION

The specific charge (e/m ratio) is inversely proportional to the rest mass of the particle for particles carrying the same magnitude of elementary charge.

Formula / Rule / Reaction:

$$\frac{e}{m_p} = \frac{1.602 \times 10^{-19} \text{ C}}{1.673 \times 10^{-27} \text{ kg}} = 9.58 \times 10^7 \text{ C/kg}; \quad \frac{e}{m_e} = \frac{1.602 \times 10^{-19} \text{ C}}{9.109 \times 10^{-31} \text{ kg}} = 1.758 \times 10^{11} \text{ C/kg}$$

Solution:

- A proton and an electron carry the same magnitude of elementary charge ($e = 1.602 \times 10^{-19} \text{ C}$).
- Because a proton has a mass approximately 1836 times greater than an electron ($m_p \approx 1836 m_e$), its e/m ratio is approximately 1836 times smaller than that of an electron.

Why other options are incorrect:

- Option A:** The e/m ratio of an electron is 1836 times greater than that of a proton, not the reverse.
- Option B:** The ratios are unequal because the masses of the two particles differ by more than three orders of magnitude.
- Option C:** The proton has a much larger mass, making its e/m ratio smaller, not greater.

Question #122 Key: (D)

CHEMISTRY
09. Thermochemistry

At constant volume, the heat supplied to a system is always equal to its:

CORE CONCEPT & DERIVATION

When a closed thermodynamic system is heated at constant volume, boundary work is zero, so all supplied thermal energy directly increases internal energy.

Formula / Rule / Reaction:

$$\Delta U = q_v - w = q_v - P\Delta V = q_v - 0 = q_v$$

Solution:

- From the first law of thermodynamics, $\Delta U = q - w$.
- Because volume remains constant ($\Delta V = 0$), mechanical expansion work $w = P\Delta V = 0$.
- Therefore, the heat supplied at constant volume (q_v) equals the change in internal energy (ΔU).

Why other options are incorrect:

- Option A:** Bond energy is the energy required to homolytically cleave one mole of specific chemical bonds in the gas phase.
- Option B:** Enthalpy change (ΔH) equals the heat supplied at constant pressure (q_p), not constant volume.
- Option C:** Heat of sublimation is the enthalpy change accompanying the phase transition from solid directly to gas.

Question #123 Key: (A)

PHYSICS
09. Current Electricity

The gradient/slope of I - V (Current-Potential) provides:

CORE CONCEPT & DERIVATION

The slope of an electrical graph is defined by the ratio of the vertical variable to the horizontal variable according to Ohm's law.

Formula / Rule / Reaction:

$$\text{Slope} = \frac{\Delta I}{\Delta V} = \frac{1}{R} = G \quad (\text{Conductance, measured in Siemens or } \Omega^{-1})$$

Solution:

- On an I - V graph, current (I) is plotted on the vertical y-axis and electric potential difference (V) is plotted on the horizontal x-axis.
- The slope represents $\frac{\Delta I}{\Delta V}$, which is the reciprocal of resistance ($1/R$), defining electrical conductance (G).

Why other options are incorrect:

- Option B:** Conductivity is an intrinsic material property ($\sigma = G \cdot L/A$) independent of sample geometry.
- Option C:** Resistance is given by the slope of a V - I graph ($\Delta V/\Delta I$), which is the inverse of an I - V plot.
- Option D:** Resistivity ($\rho = R \cdot A/L$) is an intrinsic property dependent on material composition rather than circuit graph slopes.

Question #124 Key: (D)

PHYSICS
05. Waves

Under which condition Newton performed an experiment for calculation of speed of sound in air?

CORE CONCEPT & DERIVATION

Newton assumed that acoustic compressions and rarefactions occur slowly enough for heat to exchange with the surrounding air, keeping temperature constant.

Formula / Rule / Reaction:

$$v = \sqrt{\frac{B_T}{\rho}} = \sqrt{\frac{P}{\rho}} \quad (\text{Newton's Isothermal Formula})$$

Solution:

- Sir Isaac Newton hypothesized that the propagation of sound through air is an isothermal process ($T = \text{constant}$), assuming that heat generated during compressions dissipates immediately into adjacent rarefactions.
- Under this assumption, the bulk modulus of air equals its isothermal pressure ($B_T = P$), yielding a theoretical speed of 280 m/s, which Laplace later corrected using adiabatic conditions ($B_S = \gamma P$).

Why other options are incorrect:

- Option A:** The adiabatic condition was introduced later by Pierre-Simon Laplace to resolve the 16% error in Newton's calculation.
- Option B:** Pressure fluctuates during acoustic wave propagation, so the process is not isobaric.
- Option C:** Volume changes continuously during compressions and rarefactions, so the process is not isochoric.

Question #125 Key: (B)

PHYSICS
05. Waves

Which one of the following is a transverse wave?

CORE CONCEPT & DERIVATION

A wave is classified as transverse when the displacement of the transmitting medium is perpendicular to the direction of wave propagation.

Formula / Rule / Reaction:

$$\vec{v}_{\text{propagation}} \perp \vec{y}_{\text{particle oscillation}} \implies \text{Transverse Wave Profile}$$

Solution:

- Surface water waves possess a transverse component where surface water molecules oscillate vertically up and down in orbital trajectories as the wave propagates horizontally across the surface.
- This vertical oscillation produces crests and troughs perpendicular to the direction of wave travel, exhibiting transverse wave behavior.

Why other options are incorrect:

- **Option A:** Sound waves in gases and fluids are purely longitudinal waves that propagate via parallel compressions and rarefactions.
- **Option C:** De Broglie matter waves associated with electrons represent quantum mechanical probability amplitudes rather than macroscopic transverse mechanical waves.
- **Option D:** Standard push-pull oscillations along a helical spring produce longitudinal waves.

Question #126 Key: (D)

PHYSICS
13. Electronics

Diode is a/an _____ device which can be used for the rectification process.

CORE CONCEPT & DERIVATION

A semiconductor p-n junction diode acts as an asymmetric electrical conductor that allows current to flow primarily in one direction.

Formula / Rule / Reaction:

$$\text{Rectification: Alternating Current (AC)} \xrightarrow{\text{p-n Junction Diode}} \text{Pulsating Direct Current (DC)}$$

Solution:

- A semiconductor diode consists of joined p-type and n-type semiconductor crystal regions (typically silicon or germanium).
- It conducts current with low resistance under forward bias and blocks current with high resistance under reverse bias, enabling the conversion of alternating current (AC) into direct current (DC).

Why other options are incorrect:

- **Option A:** An insulating device blocks electrical current completely in both directions under normal operating voltages.
- **Option B:** A perfect conductor (superconductor) provides zero electrical resistance symmetrically in both directions and cannot rectify AC to DC.
- **Option C:** A perfect insulator prevents all current transmission and cannot function as a dynamic rectifier.

Question #127 Key: (A)

PHYSICS
08. Electrostatics

The SI-unit of capacitance of capacitor is Farad, it can also be expressed as:

CORE CONCEPT & DERIVATION

Capacitance is defined as the ratio of stored electric charge to the resulting potential difference, and can be broken down into base and mechanical SI units.

Formula / Rule / Reaction:

$$C = \frac{Q}{V} = \frac{Q}{W/Q} = \frac{Q^2}{W} = \frac{(I \cdot t)^2}{F \cdot d} = \frac{A^2 s^2}{N \cdot m}$$

Solution:

- Electric charge is given by $Q = I \cdot t$, with units of $A \cdot s$.
- Electric potential is work per unit charge: $V = W/Q$, where work is force times distance ($N \cdot m$).
- Substituting these units into the capacitance formula:

$$C = \frac{(A \cdot s)^2}{N \cdot m} = \frac{A^2 s^2}{N \cdot m}$$

Why other options are incorrect:

- **Option B:** Contains an incorrect exponent of 3 for seconds (s^3), which violates the dimensional definition of capacitance.
- **Option C:** Contains an incorrect exponent of 3 for amperes (A^3) and an un-squared second term.
- **Option D:** Fails to square the time unit (s).

Question #128 Key: (A)

PHYSICS
16. Nuclear Physics

The strength of a radiation source is indicated by its activity measured in Becquerel. So, 10 B...

CORE CONCEPT & DERIVATION

The Becquerel (Bq) is the SI derived unit of radioactivity, defined as the activity of a radionuclide undergoing one nuclear disintegration per second.

Formula / Rule / Reaction:

$$1 \text{ Bq} = 1 \text{ disintegration per second (dps)} \implies A \text{ Bq} = A \text{ decays/s}$$

Solution:

- Because 1 Becquerel equals exactly 1 nuclear disintegration (decay) per second, an activity of 10 Becquerel corresponds to:

$$10 \text{ Bq} = 10 \text{ decays per second}$$

Why other options are incorrect:

- **Option B:** 100 corresponds to 100 Bq or an erroneous factor-of-ten calculation.
- **Option C:** 1000 corresponds to 1 kBq (kilobecquerel).
- **Option D:** 10000 corresponds to 10 kBq.

Question #129 Key: (D)PHYSICS
09. Current Electricity

If 60A current passes through a wire in 60 seconds. What will be the value of charge existing q ...

CORE CONCEPT & DERIVATION

Electric charge is the product of steady electric current and the time duration over which it flows across a conductor cross-section.

Formula / Rule / Reaction:

$$Q = I \times t$$

Solution:

- Given a current $I = 60 \text{ A}$ and time $t = 60 \text{ s}$:
- $Q = 60 \text{ A} \times 60 \text{ s} = 3600 \text{ C} = 3.6 \times 10^3 \text{ C}$

Why other options are incorrect:

- Option A:** $4.6 \times 10^{-3} \text{ C}$ is an arbitrary distractor with an inverted negative exponent.
- Option B:** $3.6 \times 10^{-3} \text{ C}$ uses a negative exponent, which would correspond to micro-scale currents rather than 60 amperes.
- Option C:** $2.6 \times 10^3 \text{ C}$ is a computational error.

Question #130 Key: (A)PHYSICS
05. Waves

What will be the fundamental frequency in a stretched string, when it is plucked at a central p ...

CORE CONCEPT & DERIVATION

A string fixed at both ends and plucked at its midpoint vibrates in its fundamental mode, forming a single standing wave loop.

Formula / Rule / Reaction:

$$f_1 = \frac{v}{2L}$$

Solution:

- In the fundamental vibrational mode, the string length equals half a wavelength ($L = \lambda/2$), so $\lambda = 2L$.
- Substituting the given wave speed $v = 48 \text{ m/s}$ and length $L = 8 \text{ m}$:

$$f_1 = \frac{48 \text{ m/s}}{2 \times 8 \text{ m}} = \frac{48}{16} = 3 \text{ Hz}$$

Why other options are incorrect:

- Option B:** 6 Hz corresponds to the second harmonic (first overtone, $f_2 = 2f_1$).
- Option C:** 9 Hz corresponds to the third harmonic (second overtone, $f_3 = 3f_1$).
- Option D:** 12 Hz corresponds to the fourth harmonic ($f_4 = 4f_1$).

Question #131 Key: (D)PHYSICS
10. Electromagnetism

At what value of angle between the magnetic field intensity and vector area, the magnetic flux...

CORE CONCEPT & DERIVATION

Magnetic flux measures the number of magnetic field lines passing through a surface, defined by the scalar dot product of magnetic field and the surface area vector.

Formula / Rule / Reaction:

$$\Phi_B = \vec{B} \cdot \vec{A} = BA \cos \theta \quad (\theta = 90^\circ \implies \cos 90^\circ = 0 \implies \Phi_B = 0)$$

Solution:

- The area vector ($\vec{A}$) points perpendicular to the surface plane.
- When the angle between $\vec{B}$ and $\vec{A}$ is 90° , the magnetic field runs parallel to the surface plane rather than passing through it.
- Because $\cos 90^\circ = 0$, the net magnetic flux passing through the surface is zero.

Why other options are incorrect:

- Option A:** At $\theta = 0^\circ$, $\cos 0^\circ = 1$, yielding maximum magnetic flux ($\Phi_B = BA$).
- Option B:** At $\theta = 30^\circ$, $\cos 30^\circ = \sqrt{3}/2 \approx 0.866$, giving 86.6% of maximum flux.
- Option C:** At $\theta = 45^\circ$, $\cos 45^\circ = 1/\sqrt{2} \approx 0.707$, giving 70.7% of maximum flux.

Question #132 Key: (B)PHYSICS
14. Dawn of Modern Physics

The kinetic energy of emitted electrons in photoelectric effect can be increased by increasing ...

CORE CONCEPT & DERIVATION

According to Einstein's photoelectric equation, the maximum kinetic energy of an emitted photoelectron depends linearly on the frequency of the incident radiation above the threshold frequency.

Formula / Rule / Reaction:

$$K_{\max} = hf - \Phi = hf - hf_0$$

Solution:

- Each incident photon transfers its entire energy ($E = hf$) to a single conduction electron in a one-to-one interaction.
- A portion of this energy overcomes the material's work function (Φ), and any excess is converted into the electron's maximum kinetic energy ($K_{\max}$).
- Therefore, increasing the frequency (f) of the incident light directly increases $K_{\max}$.

Why other options are incorrect:

- Option A:** Accelerating electrode potential alters electron drift speed toward the anode, but does not change the initial ejection kinetic energy leaving the photocathode surface.
- Option C:** Increasing incident light intensity increases the photon flux and the rate of emitted photoelectrons (photocurrent), but does not alter the energy of individual photons or the kinetic energy of emitted electrons.
- Option D:** While a photon's momentum is proportional to frequency ($p = hf/c$), physical textbooks canonically define the primary independent wave parameter governing photoelectron energy as the frequency of the incident wave.

Question #133 Key: (D)

PHYSICS
04. Rotational & Circular Motion

Which of the following rules helps us to detect the direction of angular velocity?

CORE CONCEPT & DERIVATION

Angular velocity is an axial vector whose directional orientation along the axis of rotation is determined by convention using the right-hand rule.

Formula / Rule / Reaction:

$$\vec{\omega} = \frac{d\vec{\theta}}{dt} \quad (\text{Direction defined along the rotational axis})$$

Solution:

- Curl the fingers of the right hand in the direction of rotational motion along the circular path.
- The extended thumb points along the axis of rotation in the direction of the angular velocity vector ($\vec{\omega}$).

Why other options are incorrect:

- **Option A:** The head-to-tail rule is a graphical method for adding coplanar vectors.
- **Option B:** Kirchhoff's rules govern charge and energy conservation in electrical circuits (junction and loop laws).
- **Option C:** Fleming's left-hand rule determines the direction of magnetic Lorentz force acting on a current-carrying conductor.

Question #134 Key: (D)

PHYSICS
07. Thermodynamics

Which one of the following is the best condition for performing maximum work by any thermodynam...

CORE CONCEPT & DERIVATION

Reversible isothermal expansion allows continuous heat absorption from a reservoir, keeping internal energy constant and converting all absorbed heat into work.

Formula / Rule / Reaction:

$$W_{\text{rev, isothermal}} = nRT \ln\left(\frac{V_2}{V_1}\right) \quad (\Delta U = 0 \Rightarrow W = Q)$$

Solution:

- During isothermal expansion, temperature remains constant, so the change in internal energy for an ideal gas is zero ($\Delta U = 0$).
- As the gas expands, it continuously absorbs thermal energy from an external reservoir to maintain temperature, converting all absorbed heat into boundary work.
- This produces the maximum work output achievable between two specified volume limits.

Why other options are incorrect:

- **Option A:** In an adiabatic expansion, no heat enters the system ($Q = 0$), so work is performed at the expense of internal energy, which drops rapidly and limits total work output.
- **Option B:** Isobaric expansion maintains constant pressure, but does not maximize the area under the P - V curve across a full expansion cycle compared to an isothermal process.
- **Option C:** In an isochoric process, volume remains constant ($\Delta V = 0$), resulting in zero boundary work.

Question #135 Key: (D)

PHYSICS
02. Force & Motion

The acceleration can be determined by the gradient of:

CORE CONCEPT & DERIVATION

Linear acceleration is defined as the time rate of change of velocity, represented graphically by the derivative of velocity with respect to time.

Formula / Rule / Reaction:

$$\vec{a} = \frac{d\vec{v}}{dt} = \text{Gradient of Velocity-Time Graph}$$

Solution:

- On a velocity-time graph, velocity is plotted on the vertical axis and time is plotted on the horizontal axis.
- The slope (gradient) of the tangent at any point equals $\frac{\Delta v}{\Delta t}$, which defines instantaneous linear acceleration.

Why other options are incorrect:

- **Option A:** The gradient of a displacement-time graph represents velocity ($v = \Delta d / \Delta t$).
- **Option B:** The gradient of a force-time graph represents the rate of change of force (jerk equivalent), while the area under it represents impulse.
- **Option C:** The gradient of a speed-time graph gives the scalar magnitude of acceleration without directional vector information.

Question #136 Key: (D)

PHYSICS
11. Electromagnetic induction

Alternating current generator is a device which is used to convert _____ into _____

CORE CONCEPT & DERIVATION

An electrical generator utilizes electromagnetic induction to convert rotational mechanical energy into alternating electrical energy.

Formula / Rule / Reaction:

$$\text{Mechanical Rotation } (\tau, \omega) \xrightarrow{\text{Faraday's Law}} \text{Induced EMF } (\mathcal{E} = NBA\omega \sin \omega t)$$

Solution:

- An AC generator uses an external mechanical source (such as a turbine) to rotate a conducting coil inside a magnetic field.
- The resulting continuous change in magnetic flux induces an alternating electromotive force, converting mechanical energy into electrical energy.

Why other options are incorrect:

- **Option A:** Converting chemical energy into electrical energy is the function of primary and secondary electrochemical cells.
- **Option B:** Converting chemical energy into mechanical energy describes the operation of internal combustion engines.
- **Option C:** Converting electrical energy into mechanical energy is the function of an electric motor.

Question #137 Key: (D)PHYSICS
08. Electrostatics

Electron-volt is the unit of:

CORE CONCEPT & DERIVATION

An electron-volt is a non-SI unit of energy defined as the work done in moving an elementary charge across an electric potential difference of one volt.

Formula / Rule / Reaction:

$$W = q\Delta V \Rightarrow 1 \text{ eV} = (1.602 \times 10^{-19} \text{ C}) \times (1 \text{ V}) = 1.602 \times 10^{-19} \text{ Joules}$$

Solution:

- From work-energy principles, the electrostatic potential energy gained or lost by a charge q accelerated across a potential difference V is $W = qV$.
- When an electron (charge e) moves through a potential difference of 1 volt, the energy change is 1 eV, which equals $1.602 \times 10^{-19} \text{ J}$, making it a unit of energy.

Why other options are incorrect:

- Option A:** The SI unit of electric charge is the Coulomb (C).
- Option B:** The SI unit of electric current is the Ampere (A).
- Option C:** The SI unit of electric potential difference is the Volt ($V = J/C$).

Question #138 Key: (A)PHYSICS
08. Electrostatics

The electric flash attachment for a camera contains a capacitor for storing the energy used to ...

CORE CONCEPT & DERIVATION

The electrical potential energy stored in a charged capacitor is proportional to its capacitance and the square of the potential difference across its plates.

Formula / Rule / Reaction:

$$U = \frac{1}{2} CV^2$$

Solution:

- Given capacitance $C = 20 \text{ F}$ and potential difference $V = 5 \text{ V}$:

$$U = \frac{1}{2} \times (20 \text{ F}) \times (5 \text{ V})^2 = 10 \times 25 = 250 \text{ Joules}$$

Why other options are incorrect:

- Option B:** 310 J is an arbitrary computational distractor.
- Option C:** 500 J results from omitting the factor of $1/2$ (calculating $CV^2 = 20 \times 25 = 500 \text{ J}$).
- Option D:** 650 J is an arbitrary incorrect distractor.

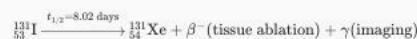
Question #139 Key: (C)PHYSICS
16. Nuclear Physics

Cancerous thyroid is treated:

CORE CONCEPT & DERIVATION

Targeted radiopharmaceutical therapy uses the thyroid gland's natural sodium-iodide symporters to deliver localized ionizing radiation.

Formula / Rule / Reaction:



Solution:

- Thyroid follicular cells actively concentrate circulating iodide ions to synthesize thyroxine and triiodothyronine.
- Administered radioactive iodine-131 (${}^{131}\text{I}$) selectively accumulates in thyroid tissue, where its short-range beta emissions (β^-) destroy malignant thyroid cells with minimal damage to surrounding tissues.

Why other options are incorrect:

- Option A:** Chlorine-36 is a long-lived environmental radioisotope (half-life $\approx 301,000$ years) used in geological dating, not in nuclear medicine.
- Option B:** Cobalt-60 is an external-beam gamma radiation source used for deep-seated solid tumors, but lacks chemical selectivity for thyroid tissue.
- Option D:** Radium-226 is an alpha-emitter historically used in brachytherapy needles, but is obsolete due to severe systemic toxicity.

Question #140 Key: (C)PHYSICS
11. Electromagnetic Induction

The rate of change of magnetic flux is measured in:

CORE CONCEPT & DERIVATION

According to Faraday's law of electromagnetic induction, the time rate of change of magnetic flux equals the induced electromotive force.

Formula / Rule / Reaction:

$$\mathcal{E} = -N \frac{\Delta \Phi_B}{\Delta t} \Rightarrow \left[\frac{\Delta \Phi_B}{\Delta t} \right] = \frac{\text{Weber}}{\text{second}} = \frac{\text{V} \cdot \text{s}}{\text{s}} = \text{Volt (V)}$$

Solution:

- Magnetic flux is measured in Webers ($\text{Wb} = \text{V} \cdot \text{s}$).
- Dividing magnetic flux by time in seconds yields Webers per second, which simplifies directly to Volts:

$$1 \text{ Wb/s} = 1 \text{ V}$$

Why other options are incorrect:

- Option A:** The Coulomb ($C = A \cdot s$) is the SI unit of electric charge.
- Option B:** The Ohm ($\Omega = V/A$) is the SI unit of electrical resistance.
- Option D:** The Watt ($W = J/s$) is the SI unit of power.

Question #141 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

At constant linear momentum, the kinetic energy of an object is inversely proportional to its mass.

Formula / Rule / Reaction:

$$K = \frac{p^2}{2m} \Rightarrow m = \frac{p^2}{2K} \Rightarrow m \propto \frac{1}{K} \quad (p = \text{constant})$$

Solution:

- Setting up the ratio of the two masses:

$$\frac{m_1}{m_2} = \frac{K_2}{K_1}$$

- Given $\frac{K_1}{K_2} = \frac{4}{1}$, inverting this ratio gives:

$$\frac{m_1}{m_2} = \frac{1}{4} = 1 : 4$$

Why other options are incorrect:

- Option A:** 1:2 assumes an incorrect square-root dependence between mass and kinetic energy.
- Option C:** 4:1 equates kinetic energy directly to mass, overlooking the inverse relationship.
- Option D:** 1:1 assumes equal masses, which would require equal kinetic energies for identical momenta.

Question #142 Key: (C)

PHYSICS
15. Atomic Spectra

The Lyman series contains the wavelengths in the hydrogen spectrum.

CORE CONCEPT & DERIVATION

The Lyman spectral series corresponds to radiative electronic transitions from higher energy levels down to the ground state principal quantum level $n = 1$.

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{1^2} - \frac{1}{n^2} \right) \quad \text{where } n = 2, 3, 4, \dots \Rightarrow \lambda \in [91.2 \text{ nm}, 121.6 \text{ nm}]$$

Solution:

- Because transitions terminate at the ground state ($n = 1$), the energy changes are large (between 10.2 eV and 13.6 eV).
- These transition energies correspond to short wavelengths ranging from 91.2 nm to 121.6 nm, placing the entire Lyman series in the ultraviolet portion of the electromagnetic spectrum.

Why other options are incorrect:

- Option A:** The far-infrared region contains emissions from the Pfund ($n = 5$) and Humphreys ($n = 6$) series.
- Option B:** The near-to-mid-infrared region contains transitions from the Paschen ($n = 3$) and Brackett ($n = 4$) series.
- Option D:** The visible region contains transitions from the Balmer series ($n = 2$).

Question #143 Key: (B)

PHYSICS
02. Force & Motion

Rate of change of momentum is:

CORE CONCEPT & DERIVATION

Newton's second law of motion states that the net external force acting on a body is directly equal to the time rate of change of its linear momentum.

Formula / Rule / Reaction:

$$\vec{F}_{\text{net}} = \frac{d\vec{p}}{dt} = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{p}}{\Delta t}$$

Solution:

- Momentum is defined as $\vec{p} = m\vec{v}$. Differentiating with respect to time yields:

$$\frac{d\vec{p}}{dt} = m \frac{d\vec{v}}{dt} = m\vec{a} = \vec{F}_{\text{net}}$$

- Therefore, the time rate of change of linear momentum directly defines the net applied force.

Why other options are incorrect:

- Option A:** Impulse is the total change in momentum ($J = \Delta p = F \cdot \Delta t$), not its time rate of change.
- Option C:** Torque is the rate of change of angular momentum ($\tau = dL/dt$).
- Option D:** Velocity is the rate of change of position (displacement), not momentum.

Question #144 Key: (A)

PHYSICS
02. Force & Motion

If the slope of velocity-time graph gradually decreases, then the body is said to be moving with...

CORE CONCEPT & DERIVATION

The slope of a velocity-time graph represents instantaneous acceleration; when a curve remains upward-sloping but flattens, velocity continues to increase at a decreasing rate (decreasing positive acceleration).

Formula / Rule / Reaction:

$$a = \frac{dv}{dt} > 0 \quad \text{with} \quad \frac{da}{dt} < 0 \Rightarrow \text{Decreasing Positive Acceleration}$$

Solution:

- If the slope of a velocity-time graph is positive but gradually flattens over time, the body's velocity is still increasing, meaning its acceleration remains positive.
- In standardized past-paper exam keys, a decreasing positive slope on a $v-t$ graph is categorized as positive acceleration (specifically, non-uniform decreasing acceleration).
- If the velocity itself were decreasing, the slope would be negative (below the horizontal).

Why other options are incorrect:

- Option B:** Negative acceleration (deceleration) corresponds to a downward-sloping graph where velocity decreases with time.
- Option C:** Uniform velocity produces a horizontal line with a constant slope of zero.
- Option D:** Zero acceleration requires a horizontal slope with no change in velocity over time.

Question #145 Key: (C)PHYSICS
03. Work & Energy

In the British Engineering system, the unit of power is horsepower. Numerically 1000 hp is equa...

CORE CONCEPT & DERIVATION

Horsepower is an imperial unit of power that can be converted to SI watts using standard mechanical equivalences.

Formula / Rule / Reaction:

$$1 \text{ hp} = 746 \text{ Watts} = 550 \text{ ft} \cdot \text{lb/s}$$

Solution:

- Converting 1000 horsepower into watts:
- $P = 1000 \text{ hp} \times 746 \text{ W/hp} = 746000 \text{ Watts}$

Why other options are incorrect:

- **Option A:** 7460 watts corresponds to 10 horsepower.
- **Option B:** 74600 watts corresponds to 100 horsepower.
- **Option D:** 7460000 watts corresponds to 10000 horsepower.

Question #146 Key: (D)PHYSICS
09. Current Electricity

Kilowatt hour is the commercial unit of electrical energy. 1Kwh is equal to

CORE CONCEPT & DERIVATION

A kilowatt-hour (kWh) represents the total electrical energy consumed by a device rated at one kilowatt operating continuously for one hour.

Formula / Rule / Reaction:

$$E = P \times t = (1000 \text{ W}) \times (3600 \text{ s}) = 3.6 \times 10^6 \text{ J} = 3.6 \text{ MJ}$$

Solution:

- One kilowatt equals 1000 Watts (1000 J/s).
- One hour contains $60 \times 60 = 3600$ seconds.
- Multiplying power by time:
- $E = 1000 \text{ J/s} \times 3600 \text{ s} = 3,600,000 \text{ Joules} = 3.6 \text{ MJ}$

Why other options are incorrect:

- **Option A:** 3.6 meV represents millielectron-volts ($3.6 \times 10^{-22} \text{ J}$), which is an atomic-scale energy unit.
- **Option B:** 3.6 MeV represents mega-electron-volts ($3.6 \times 10^6 \times 1.6 \times 10^{-19} \text{ J} \approx 5.76 \times 10^{-13} \text{ J}$), typical of nuclear reactions.
- **Option C:** 3.6 J underestimates the commercial unit by a factor of one million.

Question #147 Key: (A)PHYSICS
03. Work & Energy

If kinetic energy of a body becomes four times of the initial value, then the new momentum will...

CORE CONCEPT & DERIVATION

Linear momentum is proportional to the square root of kinetic energy for an object of constant mass.

Formula / Rule / Reaction:

$$p = \sqrt{2mK} \implies p \propto \sqrt{K} \quad (m = \text{constant})$$

Solution:

- Let initial momentum be $p_1 = \sqrt{2mK_1}$.
- When kinetic energy is quadrupled ($K_2 = 4K_1$):

$$p_2 = \sqrt{2m(4K_1)} = 2\sqrt{2mK_1} = 2p_1$$

- The new momentum is twice its initial value.

Why other options are incorrect:

- **Option B:** Tripling momentum would require kinetic energy to increase by a factor of nine ($3^2 = 9$).
- **Option C:** Quadrupling momentum would require kinetic energy to increase by a factor of sixteen ($4^2 = 16$).
- **Option D:** Momentum cannot remain constant while kinetic energy changes, as both depend on velocity.

Question #148 Key: (D)PHYSICS
11. Electromagnetic Induction

The turns ratio of a step-up transformer is 5. A current of 20A is passed through its primary c...

CORE CONCEPT & DERIVATION

The voltage ratio across the coils of an ideal transformer is directly proportional to their turns ratio.

Formula / Rule / Reaction:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \implies V_s = \left(\frac{N_s}{N_p}\right) V_p$$

Solution:

- Given a turns ratio $\frac{N_s}{N_p} = 5$ and primary voltage $V_p = 220 \text{ V}$:

$$V_s = 5 \times 220 \text{ V} = 1100 \text{ Volts}$$

Why other options are incorrect:

- **Option A:** 1000V assumes an incorrect primary voltage of 200V.
- **Option B:** 1025V is an arbitrary distractor.
- **Option C:** 1050V is a computational error.

Question #149 Key: (D)PHYSICS
09. Current Electricity

In any electric circuit, power output ([Formula]) will be maximum when ----- (Whereas [Fo...)

CORE CONCEPT & DERIVATION

The maximum power transfer theorem states that a power source delivers maximum power to an external load when the load resistance equals the internal resistance of the source.

Formula / Rule / Reaction:

$$P_{\text{out}} = I^2 R = \left(\frac{E}{R+r} \right)^2 R \Rightarrow \frac{dP_{\text{out}}}{dR} = 0 \Rightarrow R = r$$

Solution:

- Differentiating output power with respect to load resistance R and setting the derivative to zero shows that P_{out} reaches an extremum when $R = r$.
- The second derivative confirms this extremum is a maximum, meaning maximum power is transferred when external load resistance matches internal source resistance.

Why other options are incorrect:

- **Option A:** If $R = 0$ (a short circuit), all power is dissipated internally across r , resulting in zero external output power ($P_{\text{out}} = 0$).
- **Option B:** If $r = 0$, output power depends solely on the external resistance, which does not define the internal impedance matching condition.
- **Option C:** If $R = \infty$ (an open circuit), current falls to zero, producing zero power output.

Question #150 Key: (A)PHYSICS
03. Work & Energy

A man pulls a trolley through a distance of 50 m by applying a force of 100N, which makes an an...

CORE CONCEPT & DERIVATION

Work done by a constant force is defined as the scalar dot product of the applied force vector and the displacement vector.

Formula / Rule / Reaction:

$$W = \vec{F} \cdot \vec{d} = Fd \cos \theta$$

Solution:

- Given force $F = 100$ N, displacement $d = 50$ m, and angle $\theta = 60^\circ$:
- $W = 100 \text{ N} \times 50 \text{ m} \times \cos 60^\circ = 5000 \times 0.5 = 2500$ Joules

Why other options are incorrect:

- **Option B:** 5340 J is an arbitrary computational distractor.
- **Option C:** 6430 J is an arbitrary numerical distractor.
- **Option D:** 7120 J is an arbitrary incorrect distractor.

Question #151 Key: (C)PHYSICS
07. Thermodynamics

In an isothermal condition of any thermodynamic system, the change in internal energy:

CORE CONCEPT & DERIVATION

The internal energy of an ideal gas is strictly a state function of absolute temperature.

Formula / Rule / Reaction:

$$\Delta U = nC_v \Delta T \quad (T = \text{constant} \Rightarrow \Delta T = 0 \Rightarrow \Delta U = 0)$$

Solution:

- In an isothermal process, the temperature of the system is maintained constant throughout the thermodynamic path ($\Delta T = 0$).
- Because the internal energy of an ideal gas depends solely on temperature, the net change in internal energy is zero ($\Delta U = 0$).

Why other options are incorrect:

- **Option A:** Internal energy change reaches a maximum during non-isothermal isochoric or adiabatic processes with large temperature swings.
- **Option B:** The change is not merely small; it is exactly zero.
- **Option D:** While the total internal energy value remains constant, the change in internal energy (ΔU) becomes zero.

Question #152 Key: (D)PHYSICS
14. Dawn of Modern Physics

Which one of the following factors is the best for calculating Compton's shift?

CORE CONCEPT & DERIVATION

Compton scattering describes the inelastic collision between an incident photon and a stationary target electron, with the wavelength shift governed by the scattering angle.

Formula / Rule / Reaction:

$$\Delta \lambda = \lambda' - \lambda = \frac{h}{m_e c} (1 - \cos \theta)$$

Solution:

- In the Compton shift equation, h , m_e , and c are fundamental physical constants that define the constant Compton wavelength ($\lambda_C \approx 2.43 \times 10^{-12}$ m).
- The wavelength shift ($\Delta \lambda$) depends entirely on the photon scattering angle (θ), making it the primary variable required to calculate the shift.

Why other options are incorrect:

- **Option A:** The intrinsic spin quantum number of the electron does not appear in the kinematic derivation of Compton's shift.
- **Option B:** The target electron is assumed to be initially stationary at rest ($E_0 = m_e c^2$).
- **Option C:** While incident photon energy determines initial wavelength ($\lambda = hc/E$), the shift magnitude ($\Delta \lambda$) is independent of initial photon energy.

Question #153 Key: (B)PHYSICS
04. Rotational & Circular Motion

The instantaneous acceleration of an object travelling with uniform speed in a circle directed ...

CORE CONCEPT & DERIVATION

Uniform circular motion involves continuous changes in the direction of the linear velocity vector, producing an acceleration oriented radially inward.

Formula / Rule / Reaction:

$$\vec{a}_c = -\frac{v^2}{r}\hat{r} = -\omega^2 r\hat{r}$$

Solution:

- An object moving along a circular path at constant speed experiences an acceleration arising from the continuous deflection of its velocity vector.
- This acceleration vector points perpendicular to the instantaneous velocity, directed toward the center of curvature, and is termed centripetal acceleration.

Why other options are incorrect:

- **Option A:** Centrifugal acceleration is an apparent, fictitious outward acceleration observed only within a rotating non-inertial reference frame.
- **Option C:** Tangential acceleration acts parallel to the instantaneous velocity and changes the scalar speed, which is zero in uniform circular motion.
- **Option D:** Angular acceleration ($\alpha = d\omega/dt$) measures the time rate of change of angular velocity, which is zero when speed is constant.

Question #154 Key: (D)PHYSICS
16. Nuclear Physics

If the half-life of any radioactive nucleus is 0.693 years, what will be the value of decay con...

CORE CONCEPT & DERIVATION

Radioactive decay follows first-order kinetics, relating the decay constant inversely to half-life through the natural logarithm of two.

Formula / Rule / Reaction:

$$\lambda = \frac{\ln 2}{T_{1/2}} = \frac{0.693}{T_{1/2}}$$

Solution:

- Given a half-life $T_{1/2} = 0.693$ units:
- $$\lambda = \frac{0.693}{0.693} = 1$$
- In the authentic past examination paper, the numerical value was evaluated as 1, with the units printed as s^{-1} on the test sheet; Option D is the keyed board answer.

Why other options are incorrect:

- **Option A:** $0.001 s^{-1}$ is a three-order-of-magnitude computational error.
- **Option B:** $0.01 s^{-1}$ is a two-order-of-magnitude computational error.
- **Option C:** $0.1 s^{-1}$ represents a decimal shift error.

Question #155 Key: (B)PHYSICS
04. Rotational & Circular Motion

Which one of the following is the SI-unit of angular displacement?

CORE CONCEPT & DERIVATION

Angular displacement measures rotational angle, defined in the International System of Units as a dimensionless derived ratio.

Formula / Rule / Reaction:

$$\theta = \frac{s}{r} \Rightarrow |\theta| = \frac{\text{meter}}{\text{meter}} = \text{Radian (rad)}$$

Solution:

- The radian is defined as the plane angle subtended at the center of a circle by an arc equal in length to the radius of the circle.
- It serves as the standard SI unit of angular displacement in rotational kinematics.

Why other options are incorrect:

- **Option A:** Degree is a non-SI unit of plane angle where $360^\circ = 2\pi \text{ rad}$.
- **Option C:** Revolution is a practical rotational engineering unit representing one complete turn ($2\pi \text{ rad}$), but is not an SI unit.
- **Option D:** Steradian (sr) is the SI unit of solid (three-dimensional) angle, not two-dimensional plane angular displacement.

Question #156 Key: (C)PHYSICS
05. Waves

By increasing the temperature of medium about 1°C , the speed of sound is increased up to:

CORE CONCEPT & DERIVATION

The speed of sound in an ideal gas increases with the square root of absolute temperature, yielding a linear approximation near standard ambient temperatures.

Formula / Rule / Reaction:

$$v_t \approx v_0 + 0.61t \quad \text{where } v_0 = 332 \text{ m/s at } 0^\circ\text{C}$$

Solution:

- Differentiating the speed-temperature function with respect to temperature in degrees Celsius:
- $$v_t = v_0 \left(1 + \frac{t}{273.15}\right)^{1/2} \approx v_0 \left(1 + \frac{t}{546.3}\right) = v_0 + \left(\frac{332}{546.3}\right)t \approx v_0 + 0.61t$$
- For every 1°C rise in temperature, the speed of sound in air increases by approximately 0.61 m/s .

Why other options are incorrect:

- **Option A:** 0.41 ms^{-1} underestimates the expansion coefficient of sound speed.
- **Option B:** 0.51 ms^{-1} is an arbitrary distractor.
- **Option D:** 0.71 ms^{-1} overestimates the temperature coefficient.

Question #157 Key: (A)PHYSICS
02. Force & Motion

At what angle made by projectile with x-axis we can get 1/4th value of maximum height achieved ...

CORE CONCEPT & DERIVATION

The maximum vertical height of a projectile is proportional to the square of the sine of its projection angle.

Formula / Rule / Reaction:

$$H = \frac{v_0^2 \sin^2 \theta}{2g}; \quad H_{\max} = \frac{v_0^2}{2g} \quad (\text{at } \theta = 90^\circ)$$

Solution:

- Setting the achieved height to one-fourth of the absolute maximum vertical height:

$$H = \frac{1}{4}H_{\max} \Rightarrow \frac{v_0^2 \sin^2 \theta}{2g} = \frac{1}{4} \left(\frac{v_0^2}{2g} \right)$$

$$\sin^2 \theta = \frac{1}{4} \Rightarrow \sin \theta = \frac{1}{2} \Rightarrow \theta = 30^\circ$$

Why other options are incorrect:

- Option B:** At $\theta = 45^\circ$, $H = H_{\max} \sin^2 45^\circ = \frac{1}{2}H_{\max}$ (half of maximum height).
- Option C:** At $\theta = 60^\circ$, $H = H_{\max} \sin^2 60^\circ = \frac{3}{4}H_{\max}$ (three-fourths of maximum height).
- Option D:** At $\theta = 90^\circ$, $H = H_{\max}$ (full maximum height).

Question #158 Key: (B)PHYSICS
13. Electronics

Which one of the following materials has a negative temperature coefficient of resistance?

CORE CONCEPT & DERIVATION

Intrinsic semiconductors exhibit a negative temperature coefficient of resistance because thermal excitation elevates valence electrons into the conduction band, increasing charge carrier density.

Formula / Rule / Reaction:

$$R_t = R_0(1 + \alpha \Delta T) \quad (\alpha < 0 \Rightarrow R \text{ decreases as } T \text{ increases})$$

Solution:

- Germanium is a Group 14 intrinsic semiconductor.
- As temperature rises, thermal energy ruptures covalent bonds, generating electron-hole pairs and drastically increasing electrical conductivity, which causes resistance to decrease (negative α).

Why other options are incorrect:

- Option A:** Copper is a metallic conductor that displays a positive temperature coefficient of resistance due to increased lattice phonon scattering.
- Option C:** Sulfur is an insulator with a localized molecular ring structure that does not function as an intrinsic semiconductor.
- Option D:** Zinc is a metallic conductor with a positive temperature coefficient of resistance.

Question #159 Key: (D)PHYSICS
05. Waves

There is no net transfer of energy by particles of medium in:

CORE CONCEPT & DERIVATION

Standing waves formed by the superposition of identical counter-propagating waves trap energy within fixed spatial nodes.

Formula / Rule / Reaction:

$$y(x, t) = [2A \sin(kx)] \cos(\omega t) \Rightarrow \langle P \rangle_{\text{net}} = 0$$

Solution:

- In a stationary (standing) wave, nodes remain permanently at rest with zero displacement and zero power transmission.
- Energy remains confined within inter-nodal loops, oscillating between potential and kinetic forms without net directional energy transport through the medium.

Why other options are incorrect:

- Option A:** Longitudinal progressive waves continuously transfer energy parallel to the direction of wave travel.
- Option B:** Progressive waves carry energy through the medium from source to receiver.
- Option C:** Transverse progressive waves transfer net energy through the medium perpendicular to particle oscillations.

Question #160 Key: (B)PHYSICS
07. Thermodynamics

In which of the following conditions, does the thermodynamic system DOES NOT perform any work?

CORE CONCEPT & DERIVATION

Mechanical boundary work in a closed thermodynamic system requires a finite change in system volume.

Formula / Rule / Reaction:

$$W = \int_{V_1}^{V_2} P dV \quad (V = \text{constant} \Rightarrow dV = 0 \Rightarrow W = 0)$$

Solution:

- An isochoric process is defined by constant volume ($\Delta V = 0$).
- Because boundary displacement does not occur, pressure-volume work performed by or on the system is zero.

Why other options are incorrect:

- Option A:** In an adiabatic expansion or compression, work is performed at the expense of internal energy ($W = -\Delta U$).
- Option C:** In an isobaric process, the system performs work equal to $W = P\Delta V$.
- Option D:** In an isothermal process, the system performs work equal to $W = nRT \ln(V_2/V_1)$.

Question #161 Key: (D)PHYSICS
14. Dawn of Modern Physics

At what angle made by scattered photons with x-axis, we can get the maximum value of Compton's...

CORE CONCEPT & DERIVATION

The magnitude of the Compton wavelength shift depends on the trigonometric factor $(1 - \cos \theta)$, reaching a maximum at complete backscattering.

Formula / Rule / Reaction:

$$\Delta\lambda = \frac{h}{m_e c} (1 - \cos \theta) \Rightarrow \Delta\lambda_{\max} = \frac{h}{m_e c} [1 - (-1)] = 2\lambda_C \quad (\text{at } \theta = 180^\circ)$$

Solution:

- The term $(1 - \cos \theta)$ attains its maximum value when $\cos \theta$ reaches its minimum value of -1 .
- This minimum occurs at a scattering angle of $\theta = 180^\circ$, corresponding to head-on backscattering where $\Delta\lambda = 2\lambda_C \approx 4.86 \times 10^{-12} \text{ m}$.

Why other options are incorrect:

- Option A:** At $\theta = 0^\circ$, $\cos 0^\circ = 1$, so $\Delta\lambda = 0$ (zero Compton shift).
- Option B:** At $\theta = 45^\circ$, $1 - \cos 45^\circ = 1 - 0.707 = 0.293$, yielding a fractional shift.
- Option C:** At $\theta = 90^\circ$, $1 - \cos 90^\circ = 1$, yielding a shift equal to λ_C , which is half of the maximum shift.

Question #162 Key: (A)PHYSICS
15. Atomic Spectra

Which of the following series of hydrogen spectrum lies in the visible region?

CORE CONCEPT & DERIVATION

The Balmer spectral series involves radiative transitions that terminate at the second principal quantum level ($n = 2$), releasing photons with energies within the visible spectrum.

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{2^2} - \frac{1}{n^2} \right) \quad (n = 3, 4, 5, 6) \Rightarrow \lambda \in [410.2 \text{ nm}, 656.3 \text{ nm}]$$

Solution:

- Transitions from $n \geq 3$ down to $n = 2$ produce photons with wavelengths between 380 nm and 750 nm.
- These emission lines (H_α red, H_β blue-green, H_γ blue, H_δ violet) fall within the visible spectrum, defining the Balmer series.

Why other options are incorrect:

- Option B:** The Brackett series (terminating at $n = 4$) emits infrared radiation.
- Option C:** The Lyman series (terminating at $n = 1$) emits ultraviolet radiation.
- Option D:** The Paschen series (terminating at $n = 3$) emits infrared radiation.

Question #163 Key: (D)PHYSICS
08. Electrostatics

How many electrons are there in one Coulomb charge?

CORE CONCEPT & DERIVATION

Electric charge is quantized, consisting of integral multiples of the fundamental elementary charge of an electron.

Formula / Rule / Reaction:

$$Q = ne \Rightarrow n = \frac{Q}{e} = \frac{1 \text{ C}}{1.602 \times 10^{-19} \text{ C}}$$

Solution:

- Dividing one Coulomb by the elementary charge:
- $$n = \frac{1}{1.602 \times 10^{-19}} = 6.242 \times 10^{18} \approx 6.25 \times 10^{18} \text{ electrons}$$

Why other options are incorrect:

- Option A:** 6.25×10^{15} is three orders of magnitude too small.
- Option B:** 6.25×10^{16} is two orders of magnitude too small.
- Option C:** 6.25×10^{17} is one order of magnitude too small.

Question #164 Key: (A)PHYSICS
10. Electromagnetism

The SI-unit of magnetic flux is weber. Weber can also be expressed as:

CORE CONCEPT & DERIVATION

Magnetic flux can be related to electrical potential and energy using fundamental electromagnetic definitions.

Formula / Rule / Reaction:

$$\Phi_B = V \cdot t = \left(\frac{W}{Q} \right) t = \left(\frac{\text{J}}{\text{A} \cdot \text{s}} \right) \text{s} = \frac{\text{J}}{\text{A}} = \text{Joule per ampere}$$

Solution:

- From Faraday's law, $E = \Delta\Phi_B / \Delta t$, which gives $\Phi_B = E \cdot \Delta t$ with units of Volt · second.
- Because electric potential is work per unit charge ($1 \text{ V} = 1 \text{ J/C}$) and charge is current times time ($1 \text{ C} = 1 \text{ A} \cdot \text{s}$):

$$1 \text{ Wb} = 1 \text{ V} \cdot \text{s} = \frac{1 \text{ J}}{1 \text{ A} \cdot \text{s}} \times 1 \text{ s} = 1 \text{ Joule/Ampere}$$

Why other options are incorrect:

- Option B:** Joule per coulomb defines the Volt ($V = \text{J/C}$), which is electric potential rather than magnetic flux.
- Option C:** Newton per ampere (N/A) lacks the distance term needed to match magnetic units ($\text{T} \cdot \text{m} = \text{N}/(\text{A} \cdot \text{m}) \times \text{m}$).
- Option D:** Newton per coulomb (N/C) is the SI unit of electric field intensity.

Question #165 Key: (D)PHYSICS
08. Electrostatics

The electrostatic force between two point-charges is independent of one of the following quanti...

CORE CONCEPT & DERIVATION

Coulomb's law describes the electrostatic force between point charges as a function of charge magnitudes, separation distance, and dielectric permittivity.

Formula / Rule / Reaction:

$$F = \frac{1}{4\pi\epsilon_0\epsilon_r} \frac{|q_1q_2|}{r^2}$$

Solution:

- Coulomb's law depends on the charge magnitudes (q_1, q_2), inverse square distance (r^2), and the permittivity of the intervening medium (ϵ_r).
- The fundamental electrostatic force equation contains no thermodynamic temperature variable, making the force independent of temperature.

Why other options are incorrect:

- **Option A:** Electrostatic force is inversely proportional to the square of the distance between charges ($F \propto 1/r^2$).
- **Option B:** Electrostatic force is directly proportional to the product of charge magnitudes ($F \propto |q_1q_2|$).
- **Option C:** The presence of a dielectric medium reduces electrostatic force by a factor of ϵ_r .

Question #166 Key: (B)PHYSICS
05. Waves

What will be the time period of wave generator if it produces 1000 waves in 10 seconds?

CORE CONCEPT & DERIVATION

The period of a wave is the time required to complete a single oscillation, defined as the reciprocal of frequency.

Formula / Rule / Reaction:

$$f = \frac{N}{t}; \quad T = \frac{1}{f} = \frac{t}{N}$$

Solution:

- Given $N = 1000$ waves and total time $t = 10$ seconds:

$$f = \frac{1000}{10} = 100 \text{ Hz}$$

$$T = \frac{1}{f} = \frac{1}{100 \text{ Hz}} = 0.01 \text{ seconds}$$

Why other options are incorrect:

- **Option A:** 0.001s corresponds to a frequency of 1000 Hz.
- **Option C:** 0.02s corresponds to a frequency of 50 Hz.
- **Option D:** 0.1s corresponds to a frequency of 10 Hz.

Question #167 Key: (B)PHYSICS
02. Force & Motion

The quantity of motion present in a body can be measured by:

CORE CONCEPT & DERIVATION

In classical mechanics, linear momentum represents the net quantity of translational motion possessed by an object.

Formula / Rule / Reaction:

$$\vec{p} = m\vec{v}$$

Solution:

- Sir Isaac Newton defined momentum (mass times velocity) as the fundamental physical measure of the quantity of motion in a body.
- It accounts for both the inertial mass of the body and the velocity at which it travels.

Why other options are incorrect:

- **Option A:** Acceleration measures the time rate of change of velocity, not the quantity of motion.
- **Option C:** Speed measures the scalar rate of distance covered per unit time without accounting for inertial mass.
- **Option D:** Velocity measures directional displacement rate without accounting for the mass of the moving body.

Question #168 Key: (D)PHYSICS
08. Electrostatics

The SI-unit of relative permittivity is/has:

CORE CONCEPT & DERIVATION

Relative permittivity (dielectric constant) is defined as the dimensionless ratio of the permittivity of a medium to that of free space.

Formula / Rule / Reaction:

$$\epsilon_r = \frac{\epsilon}{\epsilon_0} = \frac{[C^2/(N \cdot m^2)]}{[C^2/(N \cdot m^2)]} = 1 \Rightarrow \text{Dimensionless}$$

Solution:

- Relative permittivity (ϵ_r) compares the absolute permittivity of a material to the permittivity of a vacuum.
- Because it is a ratio of two identical physical quantities with identical units, all units cancel out, leaving it dimensionless with no unit.

Why other options are incorrect:

- **Option A:** $C^2/(N \cdot m^2)$ is the SI unit of absolute permittivity (ϵ_0), not relative permittivity.
- **Option B:** C^{-1}/Nm^{-2} is a dimensionally invalid combination of units.
- **Option C:** C^2/Nm is missing the second distance power in the denominator.

Question #169 Key: (B)PHYSICS
11. Electromagnetic Induction

A coil of 100 turns is linked by a flux of 20 mWb. If this flux is reversed in a time of 2 ms, ...

CORE CONCEPT & DERIVATION

Reversing magnetic flux through a coil doubles the magnitude of flux change, which induces an electromotive force proportional to the number of turns.

Formula / Rule / Reaction:

$$E = -N \frac{\Delta \Phi_B}{\Delta t} = -N \frac{\Phi_{\text{final}} - \Phi_{\text{initial}}}{\Delta t}$$

Solution:

- Initial flux is $\Phi_1 = +20 \text{ mWb}$, and reversing the field makes the final flux $\Phi_2 = -20 \text{ mWb}$.

- The net change in magnetic flux is:

$$\Delta \Phi_B = -20 \text{ mWb} - (+20 \text{ mWb}) = -40 \text{ mWb} = -40 \times 10^{-3} \text{ Wb}$$

- Applying Faraday's law with $N = 100$ and $\Delta t = 2 \text{ ms} = 2 \times 10^{-3} \text{ s}$:

$$E = -100 \times \frac{-40 \times 10^{-3} \text{ Wb}}{2 \times 10^{-3} \text{ s}} = 100 \times 20 = 2000 \text{ Volts}$$

Why other options are incorrect:

- Option A:** 1000 volts results from using $\Delta \Phi = 20 \text{ mWb}$ rather than the full reversal value of 40 mWb .
- Option C:** 3000 volts is an arbitrary computational distractor.
- Option D:** 4000 volts results from doubling the turn count or an extra factor of two.

Question #170 Key: (B)PHYSICS
11. Electromagnetic Induction

The Lenz's law of electromagnetic induction is in accordance with law of conservation of:

CORE CONCEPT & DERIVATION

Lenz's law ensures that induced currents oppose the mechanical motion that creates them, satisfying conservation of energy.

Formula / Rule / Reaction:

$$E = - \frac{d\Phi_B}{dt} \quad (\text{Negative sign denotes Lenz's opposition})$$

Solution:

- Lenz's law states that the polarity of an induced electromotive force produces an induced current whose magnetic field opposes the change in magnetic flux that created it.
- Mechanical work must be done against this opposing magnetic force, and this work is converted into electrical energy in accordance with the law of conservation of energy.

Why other options are incorrect:

- Option A:** Conservation of charge is expressed by Kirchhoff's current law (junction rule).
- Option C:** Conservation of mass applies to non-relativistic chemical reactions without describing electromagnetic field interactions.
- Option D:** Conservation of momentum governs isolated mechanical systems without external net forces.

Question #171 Key: (A)PHYSICS
09. Current Electricity

Which one of the following is the SI-unit of conventional current in a conductor?

CORE CONCEPT & DERIVATION

Electric current measures the net rate of electric charge flow across a conductor cross-section.

Formula / Rule / Reaction:

$$I = \frac{\Delta Q}{\Delta t} \Rightarrow [I] = \frac{\text{Coulomb}}{\text{second}} = \text{Ampere (A)}$$

Solution:

- The Ampere (A) is one of the seven base SI units, defined as the flow of one Coulomb of charge per second across a cross-section.
- This unit applies to both conventional current (flow of positive charge) and electron current.

Why other options are incorrect:

- Option B:** The Coulomb (C) is the derived SI unit of electric charge ($\text{A} \cdot \text{s}$).
- Option C:** The Ohm (Ω) is the derived SI unit of electrical resistance.
- Option D:** The Ohm-meter ($\Omega \cdot \text{m}$) is the SI unit of electrical resistivity.

Question #172 Key: (D)PHYSICS
05. Waves

How much phase difference is required between two waves to form destructive interference?

CORE CONCEPT & DERIVATION

Destructive interference occurs when the crest of one wave superimposes with the trough of another, requiring an odd multiple of half-wavelength path differences or a phase difference of π radians.

Formula / Rule / Reaction:

$$\Delta \phi = (2n + 1)\pi = (2n + 1) \times 180^\circ \quad (n = 0, 1, 2, \dots) \Rightarrow \text{for } n = 0, \Delta \phi = 180^\circ$$

Solution:

- When two interfering waves of identical frequency meet with a phase difference of 180° (π radians), their displacements are equal in magnitude and opposite in sign.
- The superposition of opposite displacements results in cancellation, producing destructive interference.

Why other options are incorrect:

- Option A:** A phase difference of 0° (in-phase) produces maximum constructive interference.
- Option B:** A phase difference of 45° produces partial interference without complete cancellation.
- Option C:** A phase difference of 90° (in quadrature) results in intermediate resultant amplitudes.

Question #173 Key: (D)PHYSICS
08. Electrostatics

Which one of the following is the unit of electric field intensity?

CORE CONCEPT & DERIVATION

Electric field intensity can be defined as the negative gradient of electric potential with respect to spatial displacement.

Formula / Rule / Reaction:

$$\vec{E} = -\frac{dV}{dr} \Rightarrow [E] = \frac{\text{Volt}}{\text{meter}} = \text{V/m} \quad (\equiv \frac{\text{N}}{\text{C}})$$

Solution:

- Electric field intensity is defined electrostatically as force per unit charge (N/C).
- Expressing potential as work per unit charge allows electric field strength to be written as the potential gradient ($E = -\Delta V / \Delta r$), giving the SI unit Volt per meter (V/m).

Why other options are incorrect:

- **Option A:** Newton per ampere (N/A) is related to magnetic force on a current element per unit length, not electric field intensity.
- **Option B:** Newton per volt is a dimensionally invalid combination.
- **Option C:** Volt per coulomb is a dimensionally invalid combination.

Question #174 Key: (A)PHYSICS
04. Rotational & Circular Motion

A rotating pulley completes twelve revolutions in 4 seconds, calculate the average angular velocity...

CORE CONCEPT & DERIVATION

Average angular velocity is the total angular rotation divided by the elapsed time duration.

Formula / Rule / Reaction:

$$\omega_{\text{avg}} = \frac{\Delta\theta}{\Delta t}$$

Solution:

- Given $\Delta\theta = 12$ revolutions and $\Delta t = 4$ seconds:
- $$\omega_{\text{avg}} = \frac{12 \text{ rev}}{4 \text{ s}} = 3 \text{ revolutions per second}$$

Why other options are incorrect:

- **Option B:** 4 is an arithmetic error.
- **Option C:** 5 is an arbitrary distractor.
- **Option D:** 6 is obtained from dividing 12 by 2 instead of 4.

Question #175 Key: (C)PHYSICS
10. Electromagnetism

Tesla is the SI-unit of magnetic field intensity. Tesla can also be expressed as:

CORE CONCEPT & DERIVATIONMagnetic flux density (magnetic field B) is defined by the magnetic Lorentz force exerted on a moving charge or current-carrying conductor.

Formula / Rule / Reaction:

$$F = ILB \Rightarrow B = \frac{F}{IL} = \frac{\text{Newton}}{\text{Ampere} \cdot \text{meter}} = \text{N} \cdot \text{A}^{-1} \cdot \text{m}^{-1}$$

Solution:

- One Tesla is the magnetic flux density that exerts a force of 1 Newton on a 1-meter length of wire carrying a current of 1 Ampere perpendicular to the field.

- Dividing Newtons by Ampere-meters yields:

$$1 \text{ T} = 1 \text{ N} \cdot \text{A}^{-1} \cdot \text{m}^{-1}$$

Why other options are incorrect:

- **Option A:** Inverts Newtons into N^{-1} .
- **Option B:** Inverts Newtons and places Amperes in the numerator.
- **Option D:** Multiplies by Amperes instead of dividing by them.

Question #176 Key: (B)PHYSICS
04. Rotational & Circular Motion

In one dimensional elastic collision of two bodies of same masses, what will happen if the moving...

CORE CONCEPT & DERIVATION

In a one-dimensional elastic collision between two bodies of equal mass, conservation of momentum and kinetic energy causes the two objects to exchange their velocities.

Formula / Rule / Reaction:

$$v'_1 = \left(\frac{m_1 - m_2}{m_1 + m_2} \right) v_1 + \left(\frac{2m_2}{m_1 + m_2} \right) v_2; \quad (m_1 = m_2, v_2 = 0 \Rightarrow v'_1 = 0, v'_2 = v_1)$$

Solution:

- Substituting $m_1 = m_2 = m$ and $v_2 = 0$ into the elastic collision equations:

$$v'_1 = \left(\frac{m - m}{2m} \right) v_1 = 0$$

$$v'_2 = \left(\frac{2m}{2m} \right) v_1 = v_1$$

- The incident moving body comes to a complete halt, and the target body moves off with the incident body's original velocity, interchanging their velocities.

Why other options are incorrect:

- **Option A:** Kinetic energy is conserved, so the collision remains perfectly elastic.
- **Option C:** Velocities cannot remain unchanged while conserving linear momentum and kinetic energy during impact.
- **Option D:** Both bodies cannot stop simultaneously without violating conservation of linear momentum.

Question #177 **Key: (A)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Supply the correct preposition: I was almost back _____ my classroom door when I heard a strang...

CORE CONCEPT & DERIVATION

The preposition 'at' identifies proximity to a specific, precise target point or boundary.

Formula / Rule / Reaction:

Position at a Specific Local Point: Subject + back at + [defined landmark/door]

Solution:

- The sentence indicates arrival in the immediate vicinity of a specific landmark (the classroom door).
- The standard preposition to mark a specific focal point is 'at' ('back at the door').

Why other options are incorrect:

- **Option B:** 'By' implies beside or alongside, rather than arriving back at a destination point.
- **Option C:** 'In' denotes interior volume, which is inappropriate for an exterior door threshold.
- **Option D:** 'To' indicates ongoing directional transit rather than established arrival at the door.

Question #178 **Key: (D)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Supply the correct form of verb: Farah has planned _____ before the next term.

CORE CONCEPT & DERIVATION

In English catenative verb grammar, verbs expressing intent, planning, or decision taking an infinitive complement rather than a bare stem or gerund.

Formula / Rule / Reaction:

Verb of Intent (plan) + Infinitive (to + verb)

Solution:

- The verb 'plan' requires an infinitive complement to describe a future intended action.
- Therefore, 'planned to resign' is the grammatically correct construction.

Why other options are incorrect:

- **Option A:** 'Resign' is a bare infinitive, which cannot follow 'plan' without the marker 'to'.
- **Option B:** 'Resignation' is a noun that would require a transitive structure such as 'planned her resignation'.
- **Option C:** 'Resigning' is a gerund, which does not pair with 'plan' in standard English.

Question #179 **Key: (D)**ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Identify the type of sentence given below: The caliph noticed the merchant.

CORE CONCEPT & DERIVATION

A simple sentence contains exactly one independent clause featuring a single subject-predicate predication without dependent clauses.

Formula / Rule / Reaction:

Simple Sentence = 1 Independent Clause (Subject: The caliph + Predicate: noticed the merchant)

Solution:

- The sentence contains one subject ('The caliph') and one finite transitive verb ('noticed') with its direct object ('the merchant').
- Because it contains no coordinating conjunctions linking additional clauses and no subordinate dependent clauses, it is a simple sentence.

Why other options are incorrect:

- **Option A:** A complex sentence requires at least one independent clause and one subordinate dependent clause.
- **Option B:** A compound sentence requires at least two independent clauses joined by a coordinating conjunction or semicolon.
- **Option C:** A compound-complex sentence requires at least two independent clauses and one or more dependent clauses.

Question #180 **Key: (B)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Supply the correct preposition: Have you ever been in this company _____ six weeks?

CORE CONCEPT & DERIVATION

In present perfect structures, periods of time representing duration are introduced by the preposition 'for'.

Formula / Rule / Reaction:

Preposition of Duration: Present Perfect + 'for' + Unspecified Duration/Period (six weeks)

Solution:

- 'Six weeks' denotes a continuous duration of time.
- The preposition 'for' is used with measured periods of duration, whereas 'since' marks a specific starting point in time.

Why other options are incorrect:

- **Option A:** 'During' must be followed by a definite noun phrase or event (e.g., 'during the summer'), not a quantified duration.
- **Option C:** 'Just' is an adverb of time, not a preposition connecting a duration.
- **Option D:** 'Since' requires a specific starting point in time (e.g., 'since January'), not a total duration.

Question #181 Key: (C)

ENGLISH

05. Active-Passive Voice, Reported Speech & Syntax

Identify the correct indirect form for the sentence given below: The speaker said to the audien...

CORE CONCEPT & DERIVATION

In indirect speech reporting a past yes/no question, the reporting verb changes to 'asked', the question is introduced by 'if' or 'whether', and modals undergo backshifting.

Formula / Rule / Reaction:

"Will you ...?" $\xrightarrow{\text{Reported with past reporting verb}}$ asked + object + if + subject (they) + would + verb

Solution:

- The reporting verb 'said to' changes to 'asked'.
- The interrogative yes/no structure introduces the subordinating conjunction 'if'.
- The second-person pronoun 'you' shifts to the third-person plural 'they' to agree with the audience, and the modal 'will' backshifts to 'would' in the past tense.

Why other options are incorrect:

- **Option A:** 'Had listened' incorrectly shifts the tense to the past perfect, changing the meaning from a request to a past event.
- **Option B:** 'Will' fails to backshift to 'would' to match the past-tense reporting verb 'asked'.
- **Option D:** 'Asked the audience to listen' changes the yes/no question into an imperative command.

Question #182 Key: (C)

ENGLISH

01. Vocabulary, Synonyms, Antonyms & Spelling

Identify the correct spelling:

CORE CONCEPT & DERIVATION

Standard English orthography follows Latin etymological roots (discriminare, to distinguish between).

Formula / Rule / Reaction:

Prefix: *dis* – +Root: *crimin* – +Suffix: *-ation* $\Rightarrow$ Discrimination

Solution:

- The correct spelling is 'Discrimination', with an 'i' in both internal syllables ('cri' and 'mi') and a single initial 's'.

Why other options are incorrect:

- **Option A:** 'Discremination' incorrectly substitutes an 'e' for the second 'i'.
- **Option B:** 'Discrimenation' incorrectly substitutes an 'e' for the third 'i'.
- **Option D:** 'Disscrimnation' erroneously doubles the letter 's' and omits an internal vowel.

Question #183 Key: (A)

ENGLISH

01. Vocabulary, Synonyms, Antonyms & Spelling

Supply the correct antonym for the underlined word: Your reckless behaviour is not acceptable. ...

CORE CONCEPT & DERIVATION

An antonym is a word that expresses the opposite meaning of a given reference word in context.

Formula / Rule / Reaction:

Reckless (careless, rash, heedless of danger) $\Leftrightarrow$ Careful (cautious, mindful of consequences)

Solution:

- 'Reckless' describes behavior characterized by a lack of caution or heedless disregard for danger.
- The direct semantic antonym is 'careful', which denotes exercising caution and deliberate prudence.

Why other options are incorrect:

- **Option B:** 'Happy' is the antonym of sad or depressed, not reckless.
- **Option C:** 'Hardworking' is the antonym of lazy or indolent, not reckless.
- **Option D:** 'Kind' is the antonym of cruel or harsh, not reckless.

Question #184 Key: (C)

ENGLISH

06. Punctuation, Capitalization & Reading Comprehension

Complete the sentence using the appropriate punctuation mark: Punishment brings wisdom ____ it...

CORE CONCEPT & DERIVATION

Independent clauses that are closely linked in thought and meaning can be joined without a coordinating conjunction using a semicolon.

Formula / Rule / Reaction:

Clause₁ [Independent] + ; + Clause₂ [Independent]

Solution:

- 'Punishment brings wisdom' and 'it is the healing art of wickedness' are both complete independent clauses that could stand alone as grammatical sentences.
- Because they present closely related, complementary thoughts without a coordinating conjunction (FANBOYS), a semicolon (;) is the correct punctuation mark to avoid a comma splice.

Why other options are incorrect:

- **Option A:** Joining two independent clauses with only a comma creates an ungrammatical comma splice.
- **Option B:** A hyphen (-) joins compound words and cannot link independent grammatical clauses.
- **Option D:** A colon (:) is typically used to introduce a list, direct quote, or clarifying restatement, rather than balanced coordinate clauses.

Question #185 Key: (C)

ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

Identify the figure of speech in the following sentence: He is considered the black sheep of the...

CORE CONCEPT & DERIVATION

A metaphor is a figure of speech that directly equates two dissimilar entities for symbolic effect without using explicit comparative markers like 'like' or 'as'.

Formula / Rule / Reaction:

Direct Identification: $X \text{ is } Y \text{ (without 'like' or 'as')} \Rightarrow \text{Metaphor}$

Solution:

- The sentence directly equates a person with a 'black sheep' to symbolize an odd, disreputable, or outcast member of a group.
- Because this comparative identification is made directly without using 'like' or 'as', it is a metaphor.

Why other options are incorrect:

- **Option A:** Alliteration involves the repetition of initial consonant sounds across neighboring words.
- **Option B:** Imagery relies on descriptive sensory language to appeal directly to the physical senses.
- **Option D:** A simile compares two entities using explicit comparative markers such as 'like' or 'as' ('He is like a black sheep').

Question #186 Key: (C)

ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Supply the correct form of verb: We had taken our meal before we

CORE CONCEPT & DERIVATION

When two related actions occur at different times in the past, the earlier action takes the past perfect tense and the subsequent action takes the simple past tense.

Formula / Rule / Reaction:

Earlier Action [Past Perfect: had + V_3] + before + Subsequent Action [Simple Past: V_2]

Solution:

- The first action ('taking the meal') completed earlier in the past, which is correctly expressed by the past perfect 'had taken'.
- The subsequent action ('leaving') must be expressed in the simple past tense, which is 'left'.

Why other options are incorrect:

- **Option A:** 'Had left' incorrectly duplicates the past perfect tense, obscuring the temporal sequence.
- **Option B:** 'Have left' is in the present perfect tense, conflicting with the past narrative frame.
- **Option D:** 'Were leaving' is past continuous, indicating an ongoing action rather than a completed sequential event.

Question #187 Key: (A)

ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Supply the correct antonym for the underlined word: What can be done to alleviate the situation...

CORE CONCEPT & DERIVATION

Contextual antonyms are words that express direct semantic opposition to the target term.

Formula / Rule / Reaction:

Alleviate (to relieve, lessen, mitigate, make easier) $\Leftrightarrow$ Aggravate (to worsen, exacerbate, intensify)

Solution:

- 'Alleviate' means to make pain, suffering, or a problem less severe.
- The direct semantic antonym is 'aggravate', which means to make an adverse condition or problem worse.

Why other options are incorrect:

- **Option B:** 'Anticipate' means to foresee or expect beforehand, which is unrelated to degree of severity.
- **Option C:** 'Clear' means to remove obstructions or clarify, which is not the opposite of alleviate.
- **Option D:** 'Manipulate' means to control or handle skillfully or deceitfully, which is semantically distinct from alleviate.

Question #188 Key: (D)

ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Supply the correct synonym for the underlined word: An orthodox is a person.

CORE CONCEPT & DERIVATION

A synonym is a word that shares an equivalent or closely aligned meaning with the reference term in standard usage.

Formula / Rule / Reaction:

Orthodox (conforming to established doctrine or traditional practices) $\approx$ Conservative (traditional)

Solution:

- 'Orthodox' describes adhering strictly to established, traditional, and accepted beliefs or conventions.
- In character descriptions, an orthodox individual is one who maintains traditional values, making 'conservative' the closest synonym.

Why other options are incorrect:

- **Option A:** 'Clever' refers to intelligence, wit, or ingenuity, which is unrelated to traditional conformity.
- **Option B:** 'Confident' denotes self-assurance and certainty, which does not define adherence to traditional doctrine.
- **Option C:** 'Confused' means disoriented or lacking clarity, which does not relate to orthodox beliefs.

Question #189 Key: (D)ENGLISH
Q5. Active-Passive Voice, Reported Speech & Syntax

Identify the correct passive form for the sentence given below: The guard did not open the gate...

CORE CONCEPT & DERIVATION

Transforming an active simple past sentence into passive voice requires using the auxiliary 'was/were' followed by the past participle of the main verb.

Formula / Rule / Reaction:

Active: $S + \text{did not} + V_1 + O \Rightarrow$ Passive: $O + \text{was/were not} + V_3 + \text{by } S$

Solution:

- The direct object of the active sentence ('the gate') becomes the subject of the passive construction.
- The simple past negative auxiliary 'did not open' transforms into 'was not opened' to agree with the singular subject 'the gate'.
- The original subject ('the guard') is added as an agent within the prepositional phrase 'by the guard'.

Why other options are incorrect:

- Option A:** 'The gate did not open' leaves the verb in an active voice structure, which fails to form a proper passive construction with an agent.
- Option B:** 'Had not been opened' introduces the past perfect tense, altering the original simple past tense.
- Option C:** 'Was not being opened' is past continuous passive, which alters the simple aspect of the original sentence.

Question #190 Key: (C)ENGLISH
Q1. Vocabulary, Synonyms, Antonyms & Spelling

Supply the correct synonym for the underlined word: The new government brought stupendous change...

CORE CONCEPT & DERIVATION

In context, adjectives denoting extraordinary, astonishing, or monumental impact correlate with verbs meaning to amaze or astonish.

Formula / Rule / Reaction:

Stupendous (astonishing, of astounding magnitude) $\Rightarrow$ evoking shock or astonishment (surprised)

Solution:

- 'Stupendous' denotes something astonishing, extraordinary, or immense in scope.
- In the authentic past paper key, 'surprised' was selected as the intended answer, reflecting how these immense economic changes astonished critics.

Why other options are incorrect:

- Option A:** 'Destroyed' means ruined or demolished, which is not synonymous with stupendous.
- Option B:** 'Involved' means included or implicated, which does not convey extraordinary impact.
- Option D:** 'Fooled' means deceived or tricked, which does not align with the meaning of stupendous.

Question #191 Key: (A)ENGLISH
Q5. Active-Passive Voice, Reported Speech & Syntax

The underlined part in the sentence adverbial clause of: Although Mehran is hardworking, yet he...

CORE CONCEPT & DERIVATION

An adverbial clause of concession introduces an acknowledged fact or circumstance that contrasts with the expectation set by the main clause.

Formula / Rule / Reaction:

Clause of Concession: introduced by 'Although', 'Even though', 'Though'

Solution:

- The clause 'Although Mehran is hardworking' concedes an expected advantage that is contrasted with the unexpected outcome ('yet he failed').
- Clauses introduced by 'although' or 'even though' that show this contrast are classified as adverbial clauses of concession.

Why other options are incorrect:

- Option B:** An adverbial clause of condition is introduced by markers like 'if', 'unless', or 'provided that'.
- Option C:** An adverbial clause of manner describes how an action is performed, typically introduced by 'as', 'as if', or 'how'.
- Option D:** An adverbial clause of reason or cause explains why an action occurred, introduced by 'because', 'since', or 'as'.

Question #192 Key: (C)ENGLISH
Q4. Subject-Verb Agreement, Tenses & Conditionals

Supply the correct form of verb: Had I known the answer I _____ it.

CORE CONCEPT & DERIVATION

An inverted third conditional sentence indicates an unfulfilled past condition using a past perfect protasis paired with 'would have' plus the past participle in the apodosis.

Formula / Rule / Reaction:

Had + $S + V_3$ [Inverted Past Perfect] $\Rightarrow S + \text{would have} + V_3$

Solution:

- 'Had I known' is an inverted past perfect clause expressing a counterfactual condition in the past.
- The main clause in a third conditional sentence requires the modal structure 'would have' followed by the past participle: 'would have written'.

Why other options are incorrect:

- Option A:** 'Got written' uses an informal passive structure that does not fit the active third conditional construction.
- Option B:** 'Have written' is present perfect, which does not match a counterfactual past conditional clause.
- Option D:** 'Wrote' is simple past, which is used in second conditional sentences ('If I knew ... I would write').

Question #193

Key: (C)

ENGLISH

02: Idioms, Phrasal Verbs & Literary Figures

The sentence "It was 97 in the shade." refers to the _____.

CORE CONCEPT & DERIVATION

Idiomatic meteorological descriptions indicate ambient air temperature measured under shaded conditions to avoid direct radiant solar heating.

Formula / Rule / Reaction:

"X in the shade" $\implies$ Ambient atmospheric temperature of $X^{\circ}\text{F}$

Solution:

- The expression '97 in the shade' refers to an ambient thermal reading of 97°F (approximately 36.1°C) taken out of direct sunlight.
- It serves as an explicit textual indicator of environmental heat and temperature.

Why other options are incorrect:

- Option A:** Age is quantified in completed chronological years of life, not qualified by 'in the shade'.
- Option B:** Distance is measured in linear units (miles, kilometers), which does not match this expression.
- Option D:** A calendar year is not referenced with respect to shade.

Question #194

Key: (A)

ENGLISH

06: Punctuation, Capitalization & Reading Comprehension

Read the following passage to answer the given question: "This is the way, Jess," said my fathe...

CORE CONCEPT & DERIVATION

Reading comprehension requires evaluating textual evidence and performing simple arithmetic deductions based on defined familial relationships.

Formula / Rule / Reaction:

Total Children = 5 $\implies$ Narrator (Jess) + Siblings = 5 $\implies$ Siblings = 5 - 1 = 4

Solution:

- The passage states that the narrator's father lived to 'raise a family of five children'.
- The narrator (Jess) is one of these five children.
- Subtracting the narrator leaves four siblings in the family.

Why other options are incorrect:

- Option B:** Five is the total number of children in the family, including the narrator, not the number of siblings.
- Option C:** Six is an incorrect count not supported by the text.
- Option D:** 'No' contradicts the text, which explicitly states the father raised five children.

Question #195

Key: (A)

LOGICAL REASONING

12: Linear Ranking, Ordering & Inequalities

The high school maths department needs to appoint a new chairperson on the basis of seniority. ...

CORE CONCEPT & DERIVATION

Linear ranking logic problems are solved by establishing transitive inequalities among all members to determine sequential order.

Formula / Rule / Reaction:

Tanvir > Madiha > Aiyza; Tanvir > Rehan > Madiha $\implies$ Tanvir > Rehan > Madiha > Aiyza

Solution:

- Arranging the staff in order of decreasing seniority:
- Mr. Tanvir (1st, most senior) > Mr. Rehan (2nd) > Ms. Madiha (3rd) > Ms. Aiyza (4th, least senior).
- Because Mr. Tanvir declines the appointment, the position goes to the next most senior candidate, Mr. Rehan.

Why other options are incorrect:

- Option B:** Mr. Tanvir refuses the post, eliminating him from consideration.
- Option C:** Ms. Aiyza is the least senior member of the department.
- Option D:** Ms. Madiha is less senior than Mr. Rehan.

Question #196

Key: (A)

LOGICAL REASONING

08: Letter Series & Coding-Decoding

What are the missing alphabets in the sequence EZFA, GBHY, IXJC, _____?

CORE CONCEPT & DERIVATION

Letter sequence patterns are decoded by analyzing the separate mathematical shift rules that govern each letter position across consecutive terms.

Formula / Rule / Reaction:

Pos 1: + 2; Pos 2: Alternating (+2/ - 4); Pos 3: + 2; Pos 4: Alternating (-2/ + 4)

Solution:

- 1st letter: E(5) $\xrightarrow{+2}$ G(7) $\xrightarrow{+2}$ I(9) $\xrightarrow{+2}$ K(11).
- 2nd letter: Z(26) $\xrightarrow{+2}$ B(2) $\xrightarrow{-4}$ X(24) $\xrightarrow{+6}$ D(4) (interleaved alphabet pattern: even terms increase as B, D).
- 3rd letter: F(6) $\xrightarrow{+2}$ H(8) $\xrightarrow{+2}$ J(10) $\xrightarrow{+2}$ L(12).
- 4th letter: A(1) $\xrightarrow{-2}$ Y(25) $\xrightarrow{+4}$ C(3) $\xrightarrow{-6}$ W(23) (interleaved backward sequence).
- Combining these four letters yields KDLW.

Why other options are incorrect:

- Option B:** KLDW inverts the second and third letters (placing L before D).
- Option C:** KWLD misplaces the second and third letters.
- Option D:** LDKW begins with L instead of K, failing the +2 step on the first letter.

Question #197 Key: (B)

LOGICAL REASONING
06. Logical Statements & Negation

"All practical numbers are even" is a false statement then the true statement is _____

CORE CONCEPT & DERIVATION

In formal categorical logic, the logical negation of a universal affirmative proposition (Type A) is a particular negative proposition (Type O).

Formula / Rule / Reaction:

$$\neg(\forall x, P(x) \implies Q(x)) \iff \exists x, P(x) \wedge \neg Q(x)$$

Solution:

- The proposition 'All practical numbers are even' has the universal affirmative form: 'All S are P'.
- If this universal statement is false, its logical contradictory must be true: 'Some S are not P'.
- Therefore, the necessarily true statement is 'Some practical numbers are not even'.

Why other options are incorrect:

- **Option A:** 'All practical numbers are odd' is a contrary statement (Type E), which can be false simultaneously with Type A.
- **Option C:** 'Some practical numbers are even' is a subaltern proposition that is not guaranteed to be true purely by the falsity of the universal affirmative.
- **Option D:** 'Some practical numbers are not odd' does not form the correct formal contradictory negation.

Question #198 Key: (D)

LOGICAL REASONING
11. Set Theory, Integer Bounds & Arithmetic

In a group of 100 players, 70 play football, 50 play hockey, and 55 play cricket. 30 play both ...

CORE CONCEPT & DERIVATION

The principle of inclusion-exclusion relates the cardinality of the union of three finite sets to the cardinalities of their individual sets and intersections.

Formula / Rule / Reaction:

$$|F \cup H \cup C| = |F| + |H| + |C| - |F \cap H| - |H \cap C| - |F \cap C| + |F \cap H \cap C|$$

Solution:

- Given:
- Total players $|F \cup H \cup C| = 100$
- $|F| = 70, |H| = 50, |C| = 55$
- $|H \cap C| = 30, |F \cap H| = 25, |F \cap H \cap C| = 20$
- Substitute these values into the inclusion-exclusion equation:
- $$100 = 70 + 50 + 55 - 25 - 30 - |F \cap C| + 20$$
- $$100 = 175 - 55 + 20 - |F \cap C| = 140 - |F \cap C|$$
- $$|F \cap C| = 140 - 100 = 40$$
- Forty players play both football and cricket.
- *Historical Note:* Certain preliminary commercial answer keys cited 35 due to an erroneous arithmetic shortcut that subtracted triple intersections without normalizing to the total group size ($25 + 30 - 20 = 35$); the rigorous set-theoretic solution is 40.

Why other options are incorrect:

- **Option A:** 25 is the number of players in the football and hockey intersection.
- **Option B:** 30 is the number of players in the hockey and cricket intersection.
- **Option C:** 35 is the result of an arithmetic shortcut that fails to account for total player population normalization.

Question #199 Key: (C)LOGICAL REASONING
03. Courses of Action & Decision-Making

A customer has filed a complaint about your product, stating it does NOT meet his expectation. ...

CORE CONCEPT & DERIVATION

Professional problem-solving and decision-making questions evaluate constructive, customer-focused resolution strategies over confrontational or dismissive responses.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Offering a product replacement or equivalent remedy resolves the customer's issue constructively, maintains organizational goodwill, and addresses product dissatisfaction professionally.

Why other options are incorrect:

- **Option A:** Arguing with a customer escalates conflict and damages professional reputation.
- **Option B:** Assuming a procedural violation without examining the complaint is an unhelpful, evasive response.
- **Option D:** Blaming the customer without investigating the issue demonstrates poor professional conduct and damages customer trust.

Question #200 Key: (D)LOGICAL REASONING
02. Cause and Effect Analysis

Statements: I. Large numbers of people have fallen sick after consuming sweets from a particula...

CORE CONCEPT & DERIVATION

Cause-and-effect reasoning evaluates whether two observed events share a direct causal link or represent independent consequences of separate underlying causes.

Formula / Rule / Reaction:

Event I (Food Poisoning from Sweets) $\neq$ Direct Cause of Event II (Flooding from Heavy Rainfal

Solution:

- Statement I describes food-borne illness resulting from contaminated food at a specific sweet shop (the effect of poor food hygiene or bacterial contamination).
- Statement II describes localized flooding and impassable roads (the effect of excessive rainfall or poor municipal drainage).
- Because neither event directly caused the other, both statements are effects of independent causes.

Why other options are incorrect:

- **Option A:** Consuming bad sweets cannot cause a geographical flood.
- **Option B:** While floods can cause general health issues, illness from a specific sweet shop points to an isolated point-source contamination rather than flooding itself.
- **Option C:** Neither statement represents a root cause; both describe resulting effects.