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KMU PESHAWAR

KMU Peshawar MDCAT 2024 Official Paper

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

Official Admitting Board: Khyber Medical University Peshawar Archive Code: BEAMBE-FLP-KMU-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

The peptidoglycan cell wall is specific to:

- (A) Amoeba
- (B) Bacteria
- (C) Protozoa
- (D) Virus

Q2. BIO

Where are spindle fibres attached on a chromosome during cell division?

- (A) Centromere
- (B) Histone proteins
- (C) Nucleolus
- (D) Telomere

Q3. BIO

Which organelle contributes towards steroid production?

- (A) Endoplasmic reticulum
- (B) Golgi apparatus
- (C) Lysosome
- (D) Ribosomes

Q4. BIO

The lysosomes found in eukaryotes contain:

- (A) Hydrolytic enzymes
- (B) Meiotic enzymes
- (C) Oxidative enzymes
- (D) Mitotic enzymes

Q5. BIO

Plasma membrane is a differentially permeable membrane due to the presence of:

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

Q6. BIO

The following function or activity is NOT controlled by the autonomic nervous system:

- (A) Cardiac muscle contraction
- (B) Salivation
- (C) Smooth muscle contraction
- (D) Thoughts and emotions

Q7. BIO

A motor neuron:

- (A) Carries impulse from effectors to CNS
- (B) Carries impulse from receptors to CNS
- (C) Carries impulse from CNS to muscles
- (D) Connects sensory nerves to ganglions

Q8. BIO

Diffusion of _____ across the postsynaptic membrane causes it to depolarize:

- (A) Calcium ions
- (B) Chloride ions
- (C) Potassium ions
- (D) Sodium ions

Q9. BIO

A reflex action does not involve the:

- (A) Brain
- (B) Motor neuron
- (C) Sensory neuron
- (D) Spinal cord

Q10. BIO

What happens to the enzyme after an enzyme-catalysed reaction?

- (A) Reduced to inactive form
- (B) Becomes inert
- (C) Changes into substrate
- (D) Used for another reaction

Q11. BIO

Catalase can be activated at pH:

- (A) 1
- (B) 3
- (C) 5
- (D) 7

Q12. BIO

Enzymatic activity can be inhibited by:

- (A) Heavy metal ions
- (B) Methane
- (C) Mutase
- (D) Noble gases

Q13. BIO

A competitive inhibitor:

- (A) Accelerates the chemical reaction
- (B) Competes with the enzyme
- (C) Is irreversible
- (D) Is reversible

Q14. BIO

Wings of birds and that of flying lizards provide evidence of:

- (A) Convergent evolution
- (B) Divergent evolution
- (C) No evolution
- (D) Same origin

Q15. BIO

The embryological stages of _____ show similarity in anatomical features:

- (A) All living things
- (B) All non-vertebrates
- (C) All vertebrates
- (D) Human, jelly fish and mouse

Q16. BIO

Which enzyme is secreted in the active form?

- (A) Amylase
- (B) Lipase
- (C) Peptidase
- (D) Protease

Q17. BIO

Which hormone stimulates the secretion of gastric juice?

- (A) Cholecystokinin
- (B) Gastrin
- (C) Insulin
- (D) Secretin

Q18. BIO

In an inflammatory response, bradykinin causes:

- (A) Activation of natural killer cells
- (B) Blockage in blood vessels
- (C) Constriction of blood vessels
- (D) Leakage of fluid from blood vessels

Q19. BIO

Which of the following is an example of passive immunity?

- (A) Antibodies from mother's milk
- (B) Previous chickenpox infection
- (C) Inactivated polio vaccine
- (D) Live polio vaccine

Q20. BIO

Bacteria that lack flagella are called:

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

Q21. BIO

Antibiotics can be used against:

- (A) Herpes simplex
- (B) Influenza
- (C) Polio
- (D) Salmonella typhi

Q22. BIO

The _____ in semen facilitate the transport of sperms.

- (A) Androgen
- (B) Prostaglandins
- (C) Oxytocin
- (D) Testosterone

Q23. BIO

The acidity of urine is neutralized by:

- (A) Cowpers gland
- (B) Prostate gland
- (C) Seminal vesicle
- (D) Vas deferens

Q24. BIO

The corpus luteum is essentially formed from:

- (A) Graafian follicle
- (B) Ovum
- (C) Oogonium
- (D) Oocyte

Q25. BIO

The outer layer of uterus is called as:

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

Q26. BIO

_____ is spread through sexual contact.

- (A) Gonorrhoea
- (B) Influenza
- (C) Tuberculosis
- (D) Typhoid

Q27. BIO

The cells contained in the lacunae of the bone are called:

- (A) Chondrocytes
- (B) Osteoblasts
- (C) Osteocytes
- (D) Osteoclasts

Q28. BIO

The _____ surrounds the muscle fibre of the skeletal muscle.

- (A) Cytoplasm
- (B) Lacunae
- (C) Myofibrils
- (D) Sarcoplasm

Q29. BIO

What happens to calcium when skeletal muscles recover from contraction?

- (A) Released from the sarcoplasmic reticulum
- (B) Released from the myosin head
- (C) Pumped into the sarcoplasmic reticulum
- (D) Exchanged for sodium ions

Q30. BIO

Which of the following blood groups has anti-A and anti-B antibodies in the serum?

- (A) A
- (B) AB
- (C) B
- (D) O

Q31. BIO

What is the primary outcome of crossing over during prophase of meiosis I?

- (A) Chromosomes duplicate without any exchange of parts
- (B) Homologous chromosomes exchange different pairs leading to recombinant chromatids and increased genetic variation
- (C) Homologous chromosomes exchange identical parts, resulting in no genetic variation
- (D) Non-homologous chromosomes exchange parts

Q32. BIO

The genetic makeup that your parents have transferred to you for your hair color, makes up your:

- (A) Genotype
- (B) Karyotype
- (C) Phenotype
- (D) None of the above

Q33. BIO

Carnivorous plants have evolved mechanisms for trapping and digesting small animals. The product of this digestion is used to supplement the plant's supply of:

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

Q34. BIO

Which is true for an X-linked dominant trait?

- (A) All female offspring of the affected father will be affected
- (B) Half of the female offspring of the affected father will be affected
- (C) No male offspring of an affected mother will be affected
- (D) No female offspring of the affected father will be affected

Q35. BIO

Malpighian tubules are found in:

- (A) Earthworm
- (B) Grasshopper
- (C) Leech
- (D) Slug

Q36. BIO

Shark belongs to class:

- (A) Chondrichthyes
- (B) Echinodermata
- (C) Osteichthyes
- (D) Urochordata

Q37. BIO

Canal system is a characteristic of:

- (A) Cnidarians
- (B) Protozoans
- (C) Porifera
- (D) Segmented worms

Q38. BIO

Mantle is the feature of:

- (A) Annelids
- (B) Chordates
- (C) Echinoderms
- (D) Mussel

Q39. BIO

The production of energy is:

- (A) Faster in anaerobic respiration
- (B) Faster in aerobic respiration
- (C) Same in both types of respiration
- (D) Not associated with respiration

Q40. BIO

The pathway to the breakdown of glucose, carried out by micro-organisms, is called:

- (A) Lactic acid fermentation
- (B) Alcoholic fermentation
- (C) Cellular respiration
- (D) None of the above

Q41. BIO

Chromosome is typically made up from a combination of:

- (A) DNA and protein
- (B) DNA and RNA
- (C) RNA and lipids
- (D) RNA and proteins

Q42. BIO

Which cytoplasmic organelle make their own proteins?

- (A) Chromosomes
- (B) Golgi apparatus
- (C) Mitochondria
- (D) Smooth endoplasmic reticulum

Q43. BIO

The active movement of mitochondria in the cytoplasm is due to:

- (A) Cyclosis
- (B) Endoplasmic streaming movements
- (C) Golgi apparatus
- (D) Transfer RNA

Q44. BIO

Which part of the brain is controlling your sense of balance?

- (A) Amygdala
- (B) Cerebellum
- (C) Hippocampus
- (D) Medulla oblongata

Q45. BIO

The neurotransmitter _____ is hydrolysed by monoamine oxidase:

- (A) Acetylcholine
- (B) Adrenaline
- (C) Glutamate
- (D) Serotonin

Q46. BIO

Most of the neurons in the CNS are:

- (A) Bipolar
- (B) Multipolar
- (C) Pseudo unipolar
- (D) Unipolar

Q47. BIO

How do enzymes enable the conversion of substrates into products?

- (A) Changing equilibrium in the direction of the substrate
- (B) Increase the activation energy
- (C) Increase the substrate concentration
- (D) Lowering the activation energy

Q48. BIO

According to Lamarckism, the basis of evolution is:

- (A) Inheritance of acquired characteristics
- (B) Mutation
- (C) Natural selection
- (D) Survival of the fittest

Q49. BIO**What best describes the hind leg bones seen in the whale?**

- (A) Analogous to the fin of living fish
- (B) Fossil structure from an extinct ancestor
- (C) Homologous structure of the wings of a bat
- (D) Vestigial structures that had a function in an ancestor

Q50. BIO**Which is true about the cells found in gastric glands lining the stomach wall?**

- (A) Chief cells secrete gastrin
- (B) Hormone cells secrete intrinsic factor
- (C) Mucus cells secrete mucin
- (D) Parietal cells secrete pepsinogen

Q51. BIO**What directly triggers the activation of natural killer cells?**

- (A) Free radicals
- (B) Hydrogen peroxide
- (C) Interferons
- (D) Oxygen

Q52. BIO**Which of the following is NOT true about plasmids found in streptococci?**

- (A) Carry fewer genes than the chromosome
- (B) Replicate autonomously from the chromosome
- (C) They are considered as genetic element
- (D) The bacterial chromosome depends on plasmids for replication

Q53. BIO**Which of the following bacteria produces endospores?**

- (A) Both gram negative and positive bacteria
- (B) Gram negative
- (C) Gram positive
- (D) Mycobacteria

Q54. BIO**_____ is used in the production of Humulin?**

- (A) Bacteria
- (B) Fungi
- (C) Protozoa
- (D) Virus

Q55. BIO**Which of the following does NOT relate to smooth muscles?**

- (A) Controlled by the autonomic nervous system
- (B) Have spindle shaped cells
- (C) Line the wall of heart
- (D) Lack striations

Q56. BIO**Which term best describes an organism's physical characteristic?**

- (A) Allele
- (B) Genetic code
- (C) Genotype
- (D) Trait

Q57. BIO**What will happen with the addition of salt to water?**

- (A) Water potential will increase
- (B) Water potential will remain same
- (C) Osmotic potential will increase
- (D) Osmotic potential will remain same

Q58. BIO**Which of the following is NOT true about viruses?**

- (A) Contain DNA
- (B) Can replicate on their own
- (C) Can infect bacteria
- (D) They have a sub-cellular structure

Q59. BIO**The genetic material of _____ is bound by a lipid membrane?**

- (A) Enterovirus
- (B) Flu virus
- (C) Hepatitis A virus
- (D) Polio virus

Q60. BIO**Viruses can NOT _____.**

- (A) Crystallise
- (B) Excrete
- (C) Infect bacteria
- (D) Mutate

Q61. BIO**Where are the enzymes required for the replication of HIV virus located?**

- (A) In the protein spikes
- (B) Surrounding the viral core
- (C) Inside the capsid
- (D) Outside the capsid

Q62. BIO**The process of ATP synthesis through a combination of electrochemical and osmotic events is known as:**

- (A) Fermentation
- (B) Glycolysis
- (C) Oxidative phosphorylation
- (D) Oxidation of pyruvate to acetyl CoA

Q63. BIO**Optimum pH for pancreatic lipase is:**

- (A) 2
- (B) 4
- (C) 6
- (D) 8

Q64. BIO**Sugarcane contains _____.**

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

Q65. BIO

Sickle cell anaemia results from:

- Ⓐ Reduction in oxygen carrying capacity of haemoglobin
- Ⓑ Linkage between the polypeptide chains
- Ⓒ Single amino acid substitution in the haemoglobin molecule
- Ⓓ Viral infections of RNA viruses

Q66. BIO

Which is INCORRECT about globular proteins?

- Ⓐ Abundantly found in hair
- Ⓑ Are spherical in shape
- Ⓒ Have polypeptide chains
- Ⓓ Soluble in water

Q67. BIO

What is the ester of fatty acids and long chain alcohol called?

- Ⓐ Acylglycerol
- Ⓑ Glycerol
- Ⓒ Phospholipid
- Ⓓ Wax

Q68. BIO

Lipids, which do not contain fatty acid are:

- Ⓐ Neutral lipids
- Ⓑ Phosphatidic acids
- Ⓒ Steroids
- Ⓓ Waxes

CHEM SECTION: CHEMISTRY

Questions 69 to 122 (54 MCQs)

Q69. CHEM

Protein present in haemoglobin has _____ structure.

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

Q70. CHEM

In competitive inhibition, the inhibitor:

- (A) Binds with substrate
- (B) Competes with enzyme
- (C) Competes with substrate
- (D) Irreversibly binds with enzyme

Q71. CHEM

Which one of the following molecules has a zero-dipole moment?

- (A) BF_3
- (B) NF_3
- (C) NH_3
- (D) H_2O

Q72. CHEM

The unhybridized p orbital in sp^2 hybridization is:

- (A) In the same plane
- (B) Out of the plane
- (C) Parallel to sp^2 orbitals
- (D) Perpendicular to sp^2 orbitals

Q73. CHEM

760 torr is equal to ____ Pascal:

- (A) 1
- (B) 76
- (C) 760
- (D) 101325

Q74. CHEM

How many grams of CO_2 can be produced by thermally decomposing 10 moles of $\text{ZnCO}_3(\text{s})$?

- (A) 320
- (B) 360
- (C) 400
- (D) 440

Q75. CHEM

Molar heat of vaporization of water is:

- (A) 40.7 cal/mol
- (B) 40.7 J/mol
- (C) 40.7 kcal/mol
- (D) 40.7 kJ/mol

Q76. CHEM

Distillation under very reduced pressure is _____ distillation:

- (A) Destructive
- (B) Fractional
- (C) Steam
- (D) Vacuum

Q77. CHEM

The example of a metallic solid is:

- (A) B
- (B) C
- (C) Cu
- (D) Si

Q78. CHEM

When a crystalline substance conducts current in one direction but not through other directions of the crystal, this property is:

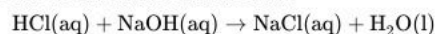
- (A) Allotropy
- (B) Anisotropy
- (C) Isomorphism
- (D) Polymorphism

Q79. CHEM

Forward reaction is the one that:

- (A) Is very slow at the beginning of the reaction
- (B) Reacts to form reactants
- (C) Speeds up gradually and at equilibrium its rate becomes constant
- (D) Takes place from left to right as given in chemical equation

Q80. CHEM

How many moles of NaCl are produced from 16.5 g of HCl , according to the neutralization reaction?

- (A) 0.252
- (B) 0.452
- (C) 0.652
- (D) 0.852

Q81. CHEM

In the production of SO_3 from SO_2 and oxygen, the yield of SO_3 is increased by:

- (A) Adding a catalyst
- (B) Adding more SO_2
- (C) Increasing temperature
- (D) Removing oxygen

Q82. CHEM

Consider $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$, $\Delta H = -92.46 \text{ kJ/mol}$. The optimum temperature ($^\circ\text{C}$) to produce ammonia is:

- (A) 0
- (B) 450
- (C) 5000
- (D) Constant temperature

Q83. CHEM

The unit of K_c for the system $\text{PCl}_5 \rightleftharpoons \text{PCl}_3 + \text{Cl}_2$ is:

- (A) dm^3/mol
- (B) mol/dm^3
- (C) mol/dm^6
- (D) mol^2/dm^6

Q84. CHEM

For a first order reaction $A \rightarrow B$, the rate constant is 0.0458 s^{-1} . Calculate rate of the reaction if the concentration of reactant is 0.35 mol dm^{-3} :

- (A) $0.012 \text{ mol dm}^{-3} \text{ s}^{-1}$
 (B) $0.014 \text{ mol dm}^{-3} \text{ s}^{-1}$
 (C) $0.016 \text{ mol dm}^{-3} \text{ s}^{-1}$
 (D) $0.018 \text{ mol dm}^{-3} \text{ s}^{-1}$

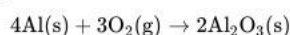
Q85. CHEM

A reaction is first order with respect to A and second order with respect to B, the rate equation is:

- (A) $\text{Rate} = k[A]$
 (B) $\text{Rate} = k[A][B]$
 (C) $\text{Rate} = k[A]^2[B]$
 (D) $\text{Rate} = k[A][B]^2$

Q86. CHEM

What mass of aluminium oxide (Al_2O_3) is produced from 18.5 g of Al metal, when it reacts completely with oxygen gas according to the following equation?



- (A) 30.8 g
 (B) 32.6 g
 (C) 34.9 g
 (D) 36.5 g

Q87. CHEM

Calculate the work done when 1 mole of an ideal gas expands from 15 dm^3 to 20 dm^3 against a constant external pressure of 2 atmospheres:

- (A) $-10 \text{ atm} \cdot \text{dm}^3$
 (B) $-5 \text{ atm} \cdot \text{dm}^3$
 (C) $5 \text{ atm} \cdot \text{dm}^3$
 (D) $10 \text{ atm} \cdot \text{dm}^3$

Q88. CHEM

When 1 mole of ice melts at 0°C and constant pressure of 1 atmosphere, 6025 J of heat is absorbed by the system. The molar volumes of ice and water are 0.020 dm^3 and 0.018 dm^3 , respectively. Calculate ΔE . ($1 \text{ dm}^3 \cdot \text{atm} = 101.33 \text{ J}$)

- (A) 6010.20 J
 (B) 6015.20 J
 (C) 6020.20 J
 (D) 6025.20 J

Q89. CHEM

One slice of bread with a tablespoon of peanut butter on it contains 20 g carbohydrate, 10 g protein, and 9 g fat. Calculate total energy consumed in this intake:

- (A) 158 kcal
 (B) 173 kcal
 (C) 201 kcal
 (D) 218 kcal

Q90. CHEM

ΔH can be measured indirectly by applying:

- (A) Avogadro's law
 (B) Faraday's law
 (C) Gas's law
 (D) Hess's law

Q91. CHEM

The heat of sublimation of potassium is 98 kJ/mol , the heat of dissociation of bromine gas is 192.5 kJ/mol . The ionization energy of K is 414 kJ/mol . The electron affinity of Br is -334.7 kJ/mol and the heat of formation of KBr is -405.8 kJ/mol . Calculate the lattice energy of KBr:

- (A) -679.3 kJ/mol
 (B) -669.5 kJ/mol
 (C) 669.5 kJ/mol
 (D) 679.3 kJ/mol

Q92. CHEM

Which one of the following is a strong electrolyte in solution?

- (A) Acetic acid
 (B) Ammonium hydroxide
 (C) Carbonic acid
 (D) Potassium iodide

Q93. CHEM

When 4 g of magnesium was heated in excess of oxygen, calculate the theoretical yield of magnesium oxide (MgO):

- (A) 3.7 g
 (B) 4.2 g
 (C) 5.4 g
 (D) 6.6 g

Q94. CHEM

The electrode potential of the standard hydrogen electrode is chosen as:

- (A) -1 V
 (B) 0 V
 (C) 1 V
 (D) 2 V

Q95. CHEM

Electronegativity of Al is approximately equal to that of:

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

Q96. CHEM

Which of the following alkali metals forms only normal oxide with O_2 ?

- (A) K
 (B) Li
 (C) Na
 (D) Rb

Q97. CHEM

Third period element that initially reacts rapidly with oxygen to form a protective oxide coating that prevents further reactions is:

- (A) Al
 (B) Mg
 (C) Na
 (D) Si

Q98. CHEM

Cu^{2+} salt solution is blue in colour due to transition of electrons from:

- (A) d to d orbital
- (B) p to d orbital
- (C) p to p orbital
- (D) s to p orbital

Q99. CHEM

Potassium ferrocyanide is which type of salt?

- (A) Complex salt
- (B) Double salt
- (C) Mixed salt
- (D) Normal salt

Q100. CHEM

Name of ketone functional group is:

- (A) Amino
- (B) Carbonyl
- (C) Carboxyl
- (D) Formyl

Q101. CHEM

Pyridine belongs to which class of organic compounds?

- (A) Alicyclic
- (B) Heterocyclic
- (C) Homocyclic
- (D) Hydrocarbon

Q102. CHEM

Which of the following elements cannot be detected directly in a given organic compound?

- (A) Chlorine
- (B) Nitrogen
- (C) Oxygen
- (D) Phosphorous

Q103. CHEM

The homolytic fission of C-H bond in an alkane result in:

- (A) Alkyl free radical
- (B) Carbanion
- (C) Carbocation
- (D) Methylpropane

Q104. CHEM

Addition of HBr to isobutylene mainly gives:

- (A) isobutyl bromide
- (B) n-butyl bromide
- (C) sec-butyl bromide
- (D) tert-butyl bromide

Q105. CHEM

Dehydrohalogenation of alkylhalide is carried out in presence of:

- (A) Alcoholic KOH
- (B) Aqueous KOH
- (C) Conc. H_2SO_4
- (D) Zn dust

Q106. CHEM

The pK_b of n-propyl amine is:

- (A) 3.24
- (B) 3.28
- (C) 3.32
- (D) 3.35

Q107. CHEM

The carbon atom carrying positive charge and attached to three other atoms or groups is called:

- (A) Carbanion
- (B) Carbene
- (C) Carbocation
- (D) Oxonium

Q108. CHEM

Which of the following has the highest boiling point?

- (A) ethyl alcohol
- (B) isopropyl alcohol
- (C) n-propyl alcohol
- (D) tert-butyl alcohol

Q109. CHEM

The reaction of an alcohol with sodium produces:

- (A) Aldehyde
- (B) Alkoxide
- (C) Ethane
- (D) Ethene

Q110. CHEM

Oxidation of secondary alcohol gives:

- (A) Carboxylic acid
- (B) Ether
- (C) Ketone
- (D) Phenol

Q111. CHEM

Which aldehyde is more reactive towards nucleophilic addition?

- (A) Acetaldehyde
- (B) Butyraldehyde
- (C) Formaldehyde
- (D) Propionaldehyde

Q112. CHEM

Acetic acid can be prepared by the hydrolysis of:

- (A) Ethanal
- (B) Ethanol
- (C) Methanoic acid
- (D) Methyl cyanide

Q113. CHEM

How many moles are there in 60g of sodium hydroxide (NaOH)?

- (A) 1.5
- (B) 4
- (C) 6
- (D) 8

Q114. CHEM

Heating 24.8g of copper carbonate (CuCO_3) in a crucible produced only 13.9g of copper oxide (CuO). What is the percentage yield of copper oxide?

- (A) 81.79%
- (B) 83.98%
- (C) 86.87%
- (D) 89.68%

Q115. CHEM

Efficiency of chemical reaction can be checked by calculating:

- (A) Actual yield
- (B) Theoretical yield
- (C) Percentage yield
- (D) Amount of the reactant unused

Q116. CHEM

Actual yield will reach the ideal (theoretical) value if the % yield of the reaction is:

- (A) 10%
- (B) 50%
- (C) 90%
- (D) 100%

Q117. CHEM

Which of the following sub-shell does not exist?

- (A) 1p
- (B) 1s
- (C) 5d
- (D) 6f

Q118. CHEM

The splitting of spectral lines in magnetic field is:

- (A) Aufbau principle
- (B) Pauli exclusion principle
- (C) Stark effect
- (D) Zeeman effect

Q119. CHEM

Which element has the electronic configuration of noble-gas notation $[\text{Kr}], 5s^2, 4d^2$?

- (A) Mo
- (B) Se
- (C) Sr
- (D) Zr

Q120. CHEM

Total number of electron pairs present in the valence shell of central atom in water are:

- (A) 2
- (B) 3
- (C) 4
- (D) 5

Q121. CHEM

What is the mass of 1 mole of calcium carbonate (CaCO_3)?

- (A) 50g
- (B) 75g
- (C) 100g
- (D) 125g

Q122. CHEM

Which one of the following molecules has a pyramidal structure?

- (A) C_2H_4
- (B) CH_4
- (C) H_2O
- (D) NH_3

PHY SECTION: PHYSICS

Questions 123 to 176 (54 MCQs)

Q123. PHY

A wheel makes 3 complete revolutions. What is the total number of radians through which a point on wheel has rotated?

- (A) 2π
- (B) 3π
- (C) 6π
- (D) 9π

Q124. PHY

For rigid body that rotates about a fixed axis, the angle swept out by a line passing through any point on the body and intersecting the axis of rotation perpendicularly is called:

- (A) Angular acceleration
- (B) Angular displacement
- (C) Angular momentum
- (D) Angular velocity

Q125. PHY

In a rotating spaceship, to produce artificial gravity, what does the centripetal force do?

- (A) Has no effect inside the spaceship
- (B) Increases spaceship's rotation
- (C) Pulls objects towards the centre
- (D) Pushes the objects towards the outer wall

Q126. PHY

When the mass of a body moving along a circle becomes half and radius becomes double, and v is constant, the centripetal force becomes:

- (A) Double
- (B) Half
- (C) One-fourth
- (D) Remains Same

Q127. PHY

What happens when two waves of the same frequency and amplitude meet in phase?

- (A) They cancel each other out resulting in a destructive interference
- (B) They combine to form a wave double the amplitude, resulting in constructive interference
- (C) They produce a wave with zero amplitude
- (D) They produce a wave with the same amplitude as the individual waves

Q128. PHY

Which type of waves can be polarized?

- (A) Longitudinal waves
- (B) Mechanical waves
- (C) Sound waves
- (D) Transverse waves

Q129. PHY

For longitudinal waves:

- (A) The particles of the medium oscillate perpendicular to the wave's propagation
- (B) The particles of the medium remain stationary as the wave passes through
- (C) The particles of the medium oscillate along the direction of the wave's propagation
- (D) Their velocity is enhanced when they travel through vacuum

Q130. PHY

According to the principle of superimposition, when 2 or more waves overlap at a point in space, the amplitude of the resultant wave at that point is:

- (A) Always zero
- (B) The product of the individual wave amplitude
- (C) The product of the frequencies of the individual waves
- (D) The sum of the amplitudes of the individual waves

Q131. PHY

The speed of sound in a medium containing ideal gas is NOT dependent on:

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

Q132. PHY

A tuning fork having frequency equal to 440Hz produces sound waves which travel with the speed of 340 m/s. What is the separation between a compression and the adjacent rarefaction of the sound waves?

- (A) 0.57 m
- (B) 0.38 m
- (C) 0.77 m
- (D) 0.87 m

Q133. PHY

A police car, with its siren on, is moving towards a stationary listener. How does the stationary listener receive the frequency of the sound emitted by the siren? It:

- (A) Decreases
- (B) Increases
- (C) Stays the same
- (D) Varies randomly

Q134. PHY

In an adiabatic process, how does the temperature of a gas change as its volume decreases?

- (A) The temperature decreases
- (B) The temperature increases
- (C) The temperature remains constant
- (D) The temperature first increases then decreases

Q135. PHY

During an isothermal expansion of an ideal gas, which of the following statement is true?

- (A) Pressure and temperature of the gas increase
- (B) The internal energy of the gas increases
- (C) The temperature of the gas remains constant
- (D) The work done by the gas is zero

Q136. PHY

Consider an ideal gas confined to the cylinder with a fixed piston, on heating the gas, all the heat supplied increases:

- (A) Kinetic energy of the molecules
- (B) Potential Energy of the molecules
- (C) The intermolecular forces between gas molecules
- (D) The number of gas molecules

Q137. PHY

What is the increase in force between two charges if the separation between them is decreased by 50 percent?

- (A) Becomes four times
- (B) Doubles
- (C) Increases by half
- (D) Triples

Q138. PHY

According to Coulomb's law, what happens to the electrostatic force between the 2-point charges if the distance between them is doubled?

- (A) The force becomes one-fourth
- (B) The force becomes half
- (C) The force doubles
- (D) The force remains the same

Q139. PHY

What does one Coulomb represent in terms of charge?

- (A) The amount of charge transported by a current of 1 Ampere in 1 second
- (B) The charge of 1 proton
- (C) The charge of 1 electron
- (D) The charge required to create a force of 1 Newton between two charges separated by 1 meter

Q140. PHY

Two points charges, $+5\mu\text{C}$ and $-5\mu\text{C}$ are placed at points A and B, respectively, which are separated by a distance $2d$. What is the electric potential at the midpoint M of the line joining A and B?

- (A) $2kQ/d$
- (B) kQ/d
- (C) $-kQ/d$
- (D) zero

Q141. PHY

In the case of a parallel plate capacitor, when the distance between the two plates is reduced to half and the area of the plate doubled, the capacitance:

- (A) Increases four times
- (B) Increases six times
- (C) Is doubled
- (D) Remains the same

Q142. PHY

If the dielectric material between the plates of the capacitor is removed, what happens to the electric field between the plates?

- (A) The electric field becomes zero
- (B) The electric field decreases
- (C) The electric field increases
- (D) The electric field remains the same

Q143. PHY

Capacitance of a capacitor increases with a decrease in:

- (A) Permittivity
- (B) Dielectric constant
- (C) Plate area
- (D) Plate separation

Q144. PHY

The I-V Graph for a non-Ohmic material is always:

- (A) Curved
- (B) Horizontal
- (C) Linear
- (D) Perpendicular

Q145. PHY

Temperature coefficient of resistance is defined as increase in resistance per ohm original resistance per ___?

- (A) Degree rise in temperature
- (B) Unit increase in electric current
- (C) Unit decrease in capacitance
- (D) Degree drop in temperature

Q146. PHY

For metals, the temperature coefficient of resistance is:

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

Q147. PHY

If R_1 and R_2 are respectively the filament resistance of a 100-Watt bulb and 200-Watt bulb designed to operate on the same voltage, then resistance of:

- (A) R_1 is two times R_2
- (B) R_2 is two times R_1
- (C) R_2 is four times R_1
- (D) R_1 is four times R_2

Q148. PHY

The maximum power transfer theorem states that maximum power is delivered to the load when:

- (A) The load resistance is half of the source resistance
- (B) The load resistance is zero
- (C) The load resistance is double the source resistance
- (D) The load resistance is equal to the source resistance

Q149. PHY

Electron Volt (eV) is another unit of:

- (A) Charge
- (B) Current
- (C) Energy
- (D) Power

Q150. PHY

An electron is moving perpendicular to the magnetic field, which of the following is correct statement about electromagnetic force acting on the electron?

- (A) Force acting is equal to electron charge
- (B) Force acting is equal to the magnetic field strength
- (C) Force acting is maximum
- (D) Zero force is acting on it

Q151. PHY

For a positive charged particle (q) moving with a velocity (v) in a magnetic field of flux density B, the force (F) acting on the charge particle is given by expression?

- (A) $q = Fv \times B$
- (B) $F = qv \times B$
- (C) $F = v \times B/q$
- (D) $q = v \times B/F$

Q152. PHY

Which of the following statement is true about the magnetic field inside a solenoid?

- (A) It is along the axis of the coil
- (B) It is circular around the wires
- (C) It is strongest at the ends of the solenoid
- (D) It is zero when current flows through it

Q153. PHY

One-meter-long copper rod is moving with speed 20 m/sec in the magnetic field of strength 0.6 tesla. What is the value of induced emf?

- (A) 12 V
- (B) 19.4 V
- (C) 20.6 V
- (D) 25 V

Q154. PHY

The inductance of a coil depends on:

- (A) Number of turns
- (B) Resistance of the wire used
- (C) Type of insulation used on the wire
- (D) Voltage applied to the coil

Q155. PHY

The direction of induced current is determined by:

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

Q156. PHY

Lenz's law is consistent with the:

- (A) Ampere's Law
- (B) Faraday's law
- (C) Law of conservation of energy
- (D) Ohm's Law

Q157. PHY

The basic principle behind the operation of the transformer is:

- (A) Coulomb's law
- (B) Electromagnetic induction
- (C) Gas's Law
- (D) Hess's law

Q158. PHY

When the PN junction is reverse-biased, its reverse current is of the order of:

- (A) Gigaamperes
- (B) Kiloamperes
- (C) Megaamperes
- (D) Microamperes

Q159. PHY

The momentum of moving photon is:

- (A) mc^2
- (B) λ/h
- (C) h/λ
- (D) zero

Q160. PHY

In every instant of time, wavelength associated with a freely falling body:

- (A) Decreases
- (B) Increases two times
- (C) Increases four times
- (D) Remains constant

Q161. PHY

As per 2nd photoelectric experiment, photoelectric effect does not occur if the frequency of the incident light is:

- (A) Below the threshold frequency
- (B) Equals the threshold frequency
- (C) Three times the threshold frequency
- (D) Twice the threshold frequency

Q162. PHY

If an electron in the hydrogen atom jumps from second to first orbit, the emitted radiation has a wavelength of:

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

Q163. PHY

Black body is an ideal radiator that radiates _____ at all wavelengths:

- (A) Inconsistently
- (B) Distinctly
- (C) Equally
- (D) Unequally

Q164. PHY

Mass number A refers to:

- (A) Number of electrons
- (B) Number of nucleons
- (C) Number of neutrons
- (D) Number of protons

Q165. PHY

λ is a _____ constant:

- (A) Decay
- (B) Dielectric
- (C) Planck's
- (D) Proportionality

Q166. PHY

Gamma ray camera can observe radiations from _____ that are concentrated in the organs:

- (A) Atoms
- (B) Isotopes
- (C) Nucleons
- (D) Neutrons

Q167. PHY

A car is moving in a circular path at a constant speed. What provides the necessary centripetal force to keep the car moving in this path?

- (A) The car's inertia resisting any change in direction
- (B) The car's mass pulling it towards the centre of the circle
- (C) The engine's power pushing the car forward
- (D) The friction between the tyres and the road

Q168. PHY

Which of the following pairs correctly matches a physical quantity with its SI unit?

- (A) Energy- Newton
- (B) Force - Joule
- (C) Power- Watt
- (D) Velocity-m/s²

Q169. PHY

_____ is the natural tendency of an object to remain at rest or in motion with constant velocity?

- (A) Friction
- (B) Inertia
- (C) Mass
- (D) Weight

Q170. PHY

A car in motion hits and gets crashed into a tree trunk, what is NOT conserved?

- (A) Kinetic energy alone
- (B) Momentum alone
- (C) Momentum and kinetic energy both
- (D) Neither kinetic energy nor momentum

Q171. PHY

The vertical and horizontal component of the projectile motion are:

- (A) Correlated with each other
- (B) Dependent on each other
- (C) Independent of each other
- (D) Associated with each other

Q172. PHY

A ball is kicked horizontally from the top of a 10m high cliff with an initial speed of 15m/s. After 2 seconds, which of the following statement describes the ball's horizontal and vertical components?

- (A) The horizontal velocity is 15m/s while vertical velocity is 20m/s downwards
- (B) The horizontal velocity is 15m/s while vertical velocity is 15m/s downwards
- (C) The horizontal velocity is 30m/s while vertical velocity is 20m/s downwards
- (D) The horizontal velocity is 15m/s while vertical velocity is 0m/s

Q173. PHY

How does an angle between the force applied and the direction of motion influence the work done on an object?

- (A) Work is constant regardless of the angle
- (B) Work is maximum when the angle is 0 degrees
- (C) Work is negative when the angle is 90 degrees
- (D) Work is 0 when the angle is 45 degrees

Q174. PHY

A nurse is pushing a wheelchair with an 80kg patient sitting on it. How much work is done by the patient's weight?

- (A) Half of the work
- (B) Maximum work
- (C) Minimum work
- (D) No work

Q175. PHY

If a constant force of 10N is applied to move an object 5m in the direction of the force, what is the work done?

- (A) 2 J
- (B) 5 J
- (C) 15 J
- (D) 50 J

Q176. PHY

The escape velocity of a body in the gravitational field of Earth is dependent on:

- (A) Angle on which it is thrown
- (B) Both mass of the body and the angle at which it is thrown
- (C) Mass of earth
- (D) Mass of the body

ENG SECTION: ENGLISH

Questions 177 to 194 (18 MCQs)

Q177. ENG

Choose the sentence with the correct tense and sentence structure:

- (A) He is going to the market yesterday.
- (B) I had been waiting for the bus, and it arrives.
- (C) She will finish her homework before she went to bed.
- (D) They were playing football when it started to rain.

Q178. ENG

Choose the correct sentence:

- (A) My father was talking to his friend on mobile phone when I fall from the bicycle.
- (B) My father is talking to his friend on mobile phone when I fall from the bicycle.
- (C) My father was talking to his friend on mobile phone when I fell from the bicycle.
- (D) My father was talking to his friend on mobile phone when I am falling from the bicycle.

Q179. ENG

Choose the correct sentence:

- (A) She didn't knew about the surprise party.
- (B) She hasn't knew about the surprise party.
- (C) She didn't know about the surprise party.
- (D) She doesn't knew about the surprise party.

Q180. ENG

After she _____ the stairs, her heart almost gave out from exhaustion.

- (A) Has climbed
- (B) Have climbed
- (C) Had climbed
- (D) Was climbing

Q181. ENG

Punctuate the given sentence correctly:

The teacher asked did you complete your homework

- (A) The teacher asked, did you complete your homework?
- (B) The teacher asked, "Did you complete your homework?"
- (C) The teacher asked, "did you complete your homework".
- (D) The teacher asked, did you complete your homework.

Q182. ENG

Punctuate the following sentence correctly:

Lets meet at Sarahs house after school

- (A) Let's meet at Sarah's house after school.
- (B) Let's meet at Sarahs' house after school.
- (C) Lets meet at Sarah's house after school.
- (D) Let's meet, at Sarah's house after school.

Q183. ENG

Do you usually take a bus _____ the market?

- (A) By
- (B) For
- (C) Of
- (D) To

Q184. ENG

He has been working _____ this project for two weeks.

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

Q185. ENG

Identify the sentence that contains an ERROR in word order, style, or vocabulary:

- (A) He has a talent for solving complex problems.
- (B) She enjoys reading, writing, and to paint.
- (C) The quick brown fox jumps over the lazy dog.
- (D) They quickly adapted to the new environment.

Q186. ENG

Identify the ERROR in the sentence:

The chef quickly prepared, delicious and it served a meal.

- (A) Punctuation
- (B) Style
- (C) Vocabulary
- (D) Word order

Q187. ENG

Order is the law of civilization as chaos is the law of the _____. The most appropriate word to be filled in is:

- (A) City
- (B) Metropolis
- (C) Universe
- (D) Wilderness

Q188. ENG

Blueprint is to architect as algorithm is to _____:

- (A) Designer
- (B) Engineer
- (C) Physician
- (D) Programmer

Q189. ENG

"Regular exercise has been shown to improve overall health by reducing the risk of chronic diseases, such as heart disease and diabetes. Additionally, exercise enhances mental well-being by reducing stress, anxiety, and depression. Despite these benefits, many people find it challenging to maintain a consistent exercise routine due to busy schedules and a lack of motivation."

Based on the paragraph, which of the following statements can be inferred?

- (A) Busy schedules and lack of motivation are barriers to regular exercise.
- (B) Chronic diseases cannot be prevented by regular exercise.
- (C) Exercise is only beneficial for physical health, not mental health.
- (D) People who exercise regularly never experience stress or anxiety.

Q190. ENG

Which of the following words is a synonym for "meticulous"?

- (A) Abhorrent
- (B) Heedless
- (C) Incautious
- (D) Precise

Q191. ENG

A person who sells goods and services is a_____:

- (A) Consumer
- (B) Purchaser
- (C) Patron
- (D) Vendor

Q192. ENG

The detective noticed a subtle change in the suspect's tone when he asked about his whereabouts on the night of the crime, which hinted at something more significant. What does "subtle" most likely mean?

- (A) Dramatic
- (B) Notable
- (C) Obvious
- (D) Slight

Q193. ENG

Despite the complicated situation, she remained _____, calmly assessing her options before deciding.

Fill in the blank with the appropriate choice:

- (A) Composed
- (B) Erratic
- (C) Frantic
- (D) Hysterical

Q194. ENG

Find out synonym of "Elated":

- (A) Confused
- (B) Disappointed
- (C) Nervous
- (D) Overjoyed

LOGIC SECTION: LOGICAL REASONING

Questions 195 to 200 (6 MCQs)

Q195. LOGIC

Read the following statements and identify the best cause-and-effect relation:

- i. Sara's productivity at work has significantly decreased over the past month.
- ii. Sara has been experiencing frequent interruptions due to ongoing construction work near her office.

Which of the following best describes the cause-and-effect relationship?

- (A) Sara's decreased productivity is causing the construction work.
- (B) The ongoing construction work is causing Sara's decreased productivity.
- (C) Sara's productivity was already decreasing before the construction work began.
- (D) The construction work is unrelated to Sara's productivity.

Q196. LOGIC

A store offers a 10% discount on all items. After applying the discount, the price of an item is Rs. 450. What was the original price of the item?

- (A) Rs. 490
- (B) Rs. 495
- (C) Rs. 500
- (D) Rs. 505

Q197. LOGIC

I went 10m to the East from my house, then turned north and walked another 15m, and then I turned west and covered 12m, and then I turned south and covered 15m. How far am I from my house?

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

Q198. LOGIC

If $a > b$, $b > c$, and $d > a$ then:

- (A) $b < d$
- (B) $a < c$
- (C) $b > d$
- (D) $c > d$

Q199. LOGIC

Find out the missing term in the sequence: 15, 14, 12, 9, ?

- (A) 5
- (B) 6
- (C) 7
- (D) 8

Q200. LOGIC

All omnivores are herbivores. No herbivores are carnivores. Some carnivores are humans.

Which of the following conclusions are TRUE?

CONCLUSIONS:

- I. Some humans are carnivores.
- II. No carnivores are omnivores.
- III. Some omnivores are carnivores.

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

OFFICIAL VERIFIED ANSWER KEY

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

SUBJECT-WISE PERFORMANCE BREAKDOWN

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

PMDC PROVINCIAL MERIT FORMULA

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

Estimated Provincial Merit Aggregate: ----- %

PROPOLIS COGNITIVE ERROR AUTOPSIES

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

Question #1 Key: (B)

BIOLOGY
01. Cell

The peptidoglycan cell wall is specific to:

CORE CONCEPT & DERIVATION

Peptidoglycan (murein) is a heteropolymer of alternating sugars and cross-linked amino acids forming the rigid structural cell wall of eubacteria.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Peptidoglycan is synthesized exclusively by bacteria to preserve cellular morphology and withstand internal osmotic turgor pressure.
- Archaea utilize pseudopeptidoglycan or S-layers, while eukaryotic organisms with walls utilize cellulose or chitin.

Why other options are incorrect:

- **Option A:** Amoeba is a unicellular eukaryotic organism bounded solely by a flexible plasma membrane, lacking any cell wall.
- **Option C:** Protozoans are single-celled eukaryotes possessing a pellicle or simple plasma membrane without peptidoglycan.
- **Option D:** Viruses are acellular biological entities consisting of a nucleic acid core encased within a protein capsid.

Question #2 Key: (A)

BIOLOGY
01. Cell

Where are spindle fibres attached on a chromosome during cell division?

CORE CONCEPT & DERIVATION

During mitotic and meiotic division, spindle microtubules physically dock onto multiprotein kinetochore complexes assembled at the centromeric region of each chromosome.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The centromere is the primary chromosomal constriction defined by specialized repetitive satellite DNA sequences.
- Kinetochore assemble directly upon centromeric chromatin to capture plus-ends of kinetochore spindle fibers, mediating poleward chromosome movement.

Why other options are incorrect:

- **Option B:** Histone octamers package nuclear DNA into nucleosomes and do not serve as attachment anchors for mitotic spindle fibers.
- **Option C:** The nucleolus is a subnuclear body dedicated to pre-ribosomal RNA transcription and disassembles during prophase.
- **Option D:** Telomeres are specialized nucleoprotein caps at the terminal ends of linear chromosomes that protect them against exonucleolytic degradation.

Question #3 Key: (A)

BIOLOGY
01. Cell

Which organelle contributes towards steroid production?

CORE CONCEPT & DERIVATION

The smooth endoplasmic reticulum possesses enzymes responsible for the synthesis of lipids, phospholipids, and steroid derivatives from cholesterol precursors.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Agranular (smooth) endoplasmic reticulum contains membrane-bound cytochrome P450 and dehydrogenase enzymes that convert cholesterol into steroid hormones.
- Steroidogenic cells in the adrenal cortex, Leydig cells of the testes, and ovarian granulosa cells contain abundant smooth endoplasmic reticulum networks.

Why other options are incorrect:

- **Option B:** The Golgi apparatus modifies, sorts, and packages glycoproteins and glycolipids rather than synthesizing sterol ring systems.
- **Option C:** Lysosomes are digestive organelles packed with acid hydrolases for intracellular degradation.
- **Option D:** Ribosomes are non-membranous ribonucleoprotein complexes dedicated exclusively to mRNA translation into polypeptides.

Question #4 Key: (A)

BIOLOGY
01. Cell

The lysosomes found in eukaryotes contain:

CORE CONCEPT & DERIVATION

Lysosomes are membrane-enclosed digestive vesicles filled with acid hydrolases that break down biological macromolecules at an acidic luminal pH.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Lysosomes house approximately 40 to 50 hydrolytic enzymes, including proteases, nucleases, glycosidases, and acid lipases.
- Proton pumps (V-type H^+ -ATPases) in the lysosomal membrane actively pump hydrogen ions into the interior to maintain an optimum working pH of 4.5 to 5.0.

Why other options are incorrect:

- **Option B:** Meiotic enzymes, such as recombinases, operate inside the nucleus during meiotic homologous recombination.
- **Option C:** Oxidative enzymes, such as catalase, urate oxidase, and peroxidase, are compartmentalized inside peroxisomes.
- **Option D:** Mitotic regulators (cyclins and cyclin-dependent kinases) operate within the nucleoplasm and cytosol.

Question #5 Key: (B)BIOLOGY
01. Cell

Plasma membrane is a differentially permeable membrane due to the presence of:

CORE CONCEPT & DERIVATION

The continuous non-polar fatty acyl core of the amphipathic phospholipid bilayer constitutes the primary physical barrier governing differential membrane permeability.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Phospholipids arrange spontaneously into an amphipathic bilayer with hydrophilic heads facing aqueous environments and hydrophobic fatty acid tails sequestered internally.
- This internal hydrophobic lipid core permits small non-polar molecules to diffuse freely while obstructing the passage of polar solutes, charged ions, and large macromolecules.

Why other options are incorrect:

- **Option A:** Membrane carbohydrates occur as external glycoproteins and glycolipids that mediate cell-to-cell recognition and adhesion.
- **Option C:** Membrane proteins function as selective channels, carriers, and receptors, but the fundamental barrier preventing free passive diffusion is the lipid layer.
- **Option D:** Vitamins are organic micronutrients and do not constitute structural permeability barriers of the membrane.

Question #6 Key: (D)BIOLOGY
12. Nervous Coordination

The following function or activity is NOT controlled by the autonomic nervous system:

CORE CONCEPT & DERIVATION

The autonomic nervous system innervates visceral effectors (smooth muscle, cardiac muscle, and glandular epithelium), whereas conscious cognition, analytical thought, and emotions are processed by higher cortical and limbic brain centers.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Sympathetic and parasympathetic motor pathways automatically regulate visceral functions to maintain homeostatic equilibrium.
- Thoughts and higher cognitive reasoning reside in the cerebral neocortex (particularly the prefrontal cortex), with emotional integration governed by the limbic system.

Why other options are incorrect:

- **Option A:** Heart rate and contraction force are modulated directly by autonomic sympathetic cardiac nerves and parasympathetic vagal branches.
- **Option B:** Salivary secretion is controlled via autonomic parasympathetic efferents running through cranial nerves VII and IX.
- **Option C:** Visceral smooth muscle contraction in vascular, gastrointestinal, and respiratory tracts is driven by autonomic motor inputs.

Question #7 Key: (C)BIOLOGY
12. Nervous Coordination

A motor neuron:

CORE CONCEPT & DERIVATION

Motor (efferent) neurons conduct action potentials centrifugally from integrating centers in the central nervous system out to peripheral effector organs, principally skeletal, cardiac, or smooth muscles.

Formula / Rule / Reaction:

$$\text{CNS} \xrightarrow{\text{Efferent / Motor Pathway}} \text{Effector (Muscle / Gland)}$$

Solution:

- Somatic motor neurons originate in the ventral gray horns of the spinal cord or cranial nerve nuclei.
- Their myelinated axons project through ventral nerve roots directly to the motor endplates of target muscle fibers, releasing acetylcholine to stimulate contraction.

Why other options are incorrect:

- **Option A:** Impulses do not propagate retrogradely from effectors back to the central nervous system under standard physiology.
- **Option B:** Sensory (afferent) neurons are responsible for conducting impulses centripetally from sensory receptors toward the central nervous system.
- **Option D:** Interneurons and preganglionic fibers establish connections within ganglia, whereas motor neurons convey output directly to effectors.

Question #8 Key: (D)BIOLOGY
12. Nervous Coordination

Diffusion of _____ across the postsynaptic membrane causes it to depolarize:

CORE CONCEPT & DERIVATION

Binding of excitatory neurotransmitters to postsynaptic ionotropic receptors opens ligand-gated cation channels, permitting an influx of sodium ions down their electrochemical gradient to generate an excitatory postsynaptic potential.

Formula / Rule / Reaction:

$$V_m \text{ shifts toward } E_{\text{Na}} \approx +60 \text{ mV (membrane depolarization)}$$

Solution:

- Resting neurons maintain a steep extracellular-to-intracellular concentration gradient for Na^+ via active Na^+/K^+ ATPase pumps.
- When ligand-gated channels open, positive Na^+ ions enter the cytoplasm, decreasing membrane electronegativity from -70 mV toward threshold.

Why other options are incorrect:

- **Option A:** Calcium influx occurs across the presynaptic terminal membrane to trigger synaptic vesicle exocytosis, rather than driving postsynaptic depolarization.
- **Option B:** Influx of Cl^- anions increases intracellular electronegativity, generating an inhibitory postsynaptic potential (hyperpolarization).
- **Option C:** Outward diffusion of K^+ down its concentration gradient drives membrane repolarization and hyperpolarization.

Question #9 Key: (A)BIOLOGY
12. Nervous Coordination*A reflex action does not involve the:***CORE CONCEPT & DERIVATION**

A somatic spinal reflex arc provides an involuntary, rapid response to noxious stimuli by integrating sensory inputs directly through spinal cord circuits without prior brain involvement.

Formula / Rule / Reaction:

Receptor → Sensory Neuron → Spinal Interneuron → Motor Neuron → Effector

Solution:

- The reflex circuit connects afferent sensory neurons directly to efferent motor neurons (or via local interneurons) inside the spinal cord gray matter.
- Although collateral tracts relay information up the spinothalamic system to inform the cerebral cortex, the motor response completes before conscious brain perception occurs.

Why other options are incorrect:

- **Option B:** Motor neurons are indispensable components that carry the final efferent signal to trigger contraction in the effector muscle.
- **Option C:** Sensory neurons represent the initial afferent pathway detecting the stimulus and propagating the action potential into the dorsal horn.
- **Option D:** The spinal cord serves as the central integration station mediating the synaptic relay of the reflex arc.

Question #10 Key: (D)BIOLOGY
03. Enzymes*What happens to the enzyme after an enzyme-catalysed reaction?***CORE CONCEPT & DERIVATION**

Enzymes operate as biological catalysts that accelerate reaction rates without undergoing permanent chemical or physical alteration at the conclusion of the catalytic cycle.

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

- Substrate molecules bind to the active site, undergo conversion to products via transition-state stabilization, and are released.
- The enzyme emerges from the catalytic cycle with its conformation intact, allowing it to bind fresh substrate molecules immediately.

Why other options are incorrect:

- **Option A:** Enzymes do not deactivate automatically following catalysis; they remain functionally active until degraded or inhibited.
- **Option B:** Enzymes retain their catalytic competence rather than turning chemically unreactive or inert.
- **Option C:** Substrates are converted into reaction products, whereas the enzyme maintains its identity as the catalytic agent.

Question #11 Key: (D)BIOLOGY
03. Enzymes*Catalase can be activated at pH:***CORE CONCEPT & DERIVATION**

Catalase is an intracellular antioxidant enzyme that exhibits optimum catalytic velocity at a neutral pH near 7.0.

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

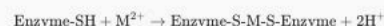
- Catalase resides primarily within peroxisomes and erythrocyte cytoplasm, where ambient physiological pH is kept neutral.
- At pH 7.0, the ionizing amino acid side chains lining the heme active site maintain the precise charge configurations required for catalytic decomposition of hydrogen peroxide.

Why other options are incorrect:

- **Option A:** A pH of 1 is an extremely acidic environment (characteristic of gastric juices for pepsin) that denatures the quaternary structure of catalase.
- **Option B:** A pH of 3 rapidly protonates critical active-site residues, causing loss of catalytic function.
- **Option C:** A pH of 5 is suboptimal and significantly suppresses catalase activity compared to its neutral optimum.

Question #12 Key: (A)BIOLOGY
03. Enzymes*Enzymatic activity can be inhibited by:***CORE CONCEPT & DERIVATION**

Heavy metal ions act as non-competitive and irreversible enzyme inhibitors by binding to reactive thiol groups, disrupting secondary and tertiary protein conformations.

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

- Divalent and trivalent cations of heavy metals such as Hg^{2+} , Pb^{2+} , Ag^+ , and Cd^{2+} react strongly with sulfhydryl (–SH) groups of cysteine residues.
- This cross-linking destroys essential disulfide bridges and alters active-site geometry, causing irreversible loss of catalytic activity.

Why other options are incorrect:

- **Option B:** Methane is a non-polar alkane gas that does not bind to or disrupt enzymatic active sites under physiological conditions.
- **Option C:** Mutase is an isomerase class of enzymes that transfers functional groups within a molecule, not an inhibitor.
- **Option D:** Noble gases possess complete valence electron shells and are chemically inert, unable to form coordinate bonds with proteins.

Question #13 Key: (D)BIOLOGY
03. Enzymes*A competitive inhibitor:***CORE CONCEPT & DERIVATION**

Competitive inhibitors bind reversibly to the free enzyme at the substrate-binding active site through non-covalent interactions.

Formula / Rule / Reaction:

$$K_m \text{ increases, } V_{\max} \text{ remains unchanged}$$

Solution:

- Because competitive inhibitors bind via non-covalent bonds (hydrogen bonds, ionic interactions, van der Waals forces), the inhibition is inherently reversible.
- Increasing substrate concentration outcompetes the inhibitor for active-site occupancy, fully restoring maximum reaction velocity ($V_{\max}$).

Why other options are incorrect:

- Option A:** Inhibitors suppress enzyme kinetics and reduce the rate of product formation rather than accelerating the reaction.
- Option B:** The inhibitor competes with the substrate for the enzyme active site, not with the enzyme itself.
- Option C:** Reversibility is the defining characteristic of classic competitive inhibition; irreversible inhibition involves covalent active-site inactivation.

Question #14 Key: (A)BIOLOGY
16. Evolution*Wings of birds and that of flying lizards provide evidence of:***CORE CONCEPT & DERIVATION**

Convergent evolution occurs when distinct biological lineages independently acquire analogous structures that fulfill similar ecological roles in response to equivalent environmental pressures.

Formula / Rule / Reaction:

$$\text{Independent Lineages} \xrightarrow{\text{Common Environmental Demand (Flight)}} \text{Analogous Structures}$$

Solution:

- Bird wings are modified pentadactyl forelimbs surfaced with feathers, whereas the gliding wings of flying lizards (*Draco*) are skin patagia supported by elongated lateral ribs.
- Because their wing structures have completely different developmental origins and anatomical plans, their functional similarity exemplifies convergent evolution.

Why other options are incorrect:

- Option B:** Divergent evolution involves homologous structures with a common ancestral origin diversifying into distinct forms (e.g., human arm, bat wing, whale flipper).
- Option C:** Morphological modifications enabling aerial locomotion are clear structural evidence of evolutionary adaptation.
- Option D:** The flight surfaces of birds and flying lizards do not share a common anatomical origin.

Question #15 Key: (C)BIOLOGY
16. Evolution*The embryological stages of _____ show similarity in anatomical features:***CORE CONCEPT & DERIVATION**

Early embryos of all vertebrate classes display conserved anatomical homologies that reveal their shared evolutionary ancestry.

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

- Early developmental stages of fish, amphibians, reptiles, birds, and mammals all transiently exhibit pharyngeal pouches, a dorsal hollow nerve cord, a notochord, and a post-anal tail.
- These conserved embryonic features reflect ancestral genetic developmental programs retained across the subphylum Vertebrata.

Why other options are incorrect:

- Option A:** Living things span entirely distinct domains (bacteria, archaea, plants, fungi) that do not share vertebrate embryology.
- Option B:** Non-vertebrate invertebrates comprise divergent phyla with distinct cleavage geometries, gastrulation mechanisms, and germ layer fates.
- Option D:** Jellyfish belong to the diploblastic phylum Cnidaria and lack triploblastic vertebrate developmental milestones.

Question #16 Key: (A)BIOLOGY
03. Enzymes*Which enzyme is secreted in the active form?***CORE CONCEPT & DERIVATION**

Amylolytic enzymes are secreted in their active form because their substrates (poly- and oligosaccharides) do not constitute internal cellular components of secretory ductal walls.

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

- Proteolytic enzymes pose an immediate danger of self-digestion to secretory cells and ducts, necessitating their secretion as inactive zymogens (e.g., trypsinogen, pepsinogen).
- Salivary and pancreatic amylases cleave internal α -(1,4)-glucosidic linkages of dietary carbohydrates and are safely secreted in an active state.

Why other options are incorrect:

- Option B:** Although pancreatic lipase is secreted in a catalytic state, it requires colipase and bile salt interfacial activation to function in the intestinal lumen; amylase is the classic textbook standard.
- Option C:** Peptidases are synthesized as inactive precursors or held membrane-bound on microvilli to safeguard enterocyte proteins.
- Option D:** Proteases are invariably synthesized and secreted as inactive proenzymes (zymogens) to prevent autolysis.

Question #17 Key: (B)BIOLOGY
06. Digestion/Nutrition

Which hormone stimulates the secretion of gastric juice?

CORE CONCEPT & DERIVATION

Gastrin is a peptide hormone produced by enteroendocrine G-cells in the gastric pyloric antrum that stimulates parietal and chief cells to secrete gastric juice.

Formula / Rule / Reaction:

Luminal Peptides / Gastric Distension $\rightarrow$ G-Cells $\xrightarrow{\text{Gastrin}}$ Parietal Cells $\rightarrow$ HCl Secretion

Solution:

- Food ingestion and gastric distension trigger G-cells to release gastrin into circulation.
- Gastrin binds to cholecystokinin-B (CCK₂) receptors on parietal cells, stimulating proton pump activation and HCl release alongside intrinsic factor.

Why other options are incorrect:

- **Option A:** Cholecystokinin stimulates gall bladder contraction and pancreatic enzyme release while inhibiting gastric emptying.
- **Option C:** Insulin promotes glucose uptake into peripheral tissues and has no role in stimulating gastric acid secretion.
- **Option D:** Secretin stimulates pancreatic ductal bicarbonate secretion and actively inhibits gastric acid secretion.

Question #18 Key: (D)BIOLOGY
08. Immunity

In an inflammatory response, bradykinin causes:

CORE CONCEPT & DERIVATION

Bradykinin is an inflammatory vasoactive nonapeptide that stimulates endothelial cell retraction, dramatically elevating vascular permeability to cause fluid extravasation.

Formula / Rule / Reaction:

Kallikrein-Kinin Activation $\rightarrow$ Bradykinin $\rightarrow$ $\uparrow$ Microvascular Permeability $\rightarrow$ Edema

Solution:

- Bradykinin binds to endothelial B₂ receptors, prompting nitric oxide and prostacyclin production.
- This promotes junctional disassembly between postcapillary venular endothelial cells, allowing plasma proteins and fluid to leak into the interstitial tissue spaces.

Why other options are incorrect:

- **Option A:** Natural killer cell activation is mediated predominantly by cytokines, including type I interferons and interleukin-12.
- **Option B:** Bradykinin maintains microcirculatory patency and vasodilation, rather than causing vessel occlusion or thrombosis.
- **Option C:** Bradykinin is a potent arteriolar vasodilator; it causes relaxation of vascular smooth muscle rather than constriction.

Question #19 Key: (A)BIOLOGY
08. Immunity

Which of the following is an example of passive immunity?

CORE CONCEPT & DERIVATION

Passive immunity involves the transfer of pre-formed immunoglobulins into a recipient without activating the recipient's own B lymphocytes or creating immunological memory.

Formula / Rule / Reaction:

Exogenous Pre-formed Antibodies $\xrightarrow{\text{Transfer}}$ Immediate, Transient Protection

Solution:

- Colostrum and breast milk deliver pre-synthesized secretory IgA directly to the infant gut lumen.
- Because the infant immune system did not generate these antibodies endogenously, protection is transient and produces no memory cells.

Why other options are incorrect:

- **Option B:** Primary infection with varicella-zoster virus generates long-lived natural active immunity with host memory cells.
- **Option C:** Inactivated polio vaccine delivers viral antigens that induce host B cells to mount an artificial active immune response.
- **Option D:** Live attenuated polio vaccine triggers mucosal and systemic artificial active immunity via host antibody synthesis.

Question #20 Key: (B)BIOLOGY
05. Acellular Life

Bacteria that lack flagella are called:

CORE CONCEPT & DERIVATION

Bacterial flagellar morphology is categorized by the presence, number, and distribution of flagellar filaments over the cellular capsule.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The prefix 'a-' denotes absence; atrichous bacteria are completely devoid of flagellar locomotion appendages.
- Common atrichous bacteria include *Corynebacterium diphtheriae* and *Pasteurella pestis*.

Why other options are incorrect:

- **Option A:** Amphitrichous bacteria possess flagella located at both opposite cellular poles.
- **Option C:** Lophotrichous bacteria feature a cluster or tuft of flagella emerging from a single pole.
- **Option D:** Peritrichous bacteria have flagella distributed uniformly over their entire outer perimeter.

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

Antibiotics can be used against:

CORE CONCEPT & DERIVATION

Antibacterial antibiotics selectively target prokaryotic biochemical structures (such as peptidoglycan walls and 70S ribosomes) that are absent in acellular viruses.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- *Salmonella typhi* is a pathogenic Gram-negative bacterium causing typhoid fever, vulnerable to antibiotics such as fluoroquinolones and third-generation cephalosporins.
- Because viral replication depends entirely on host cell metabolic machinery, standard antibacterial antibiotics have no inhibitory effect against viruses.

Why other options are incorrect:

- **Option A:** Herpes simplex is an enveloped double-stranded DNA virus treated with antiviral guanosine analogues like acyclovir.
- **Option B:** Influenza is an enveloped negative-sense RNA virus managed using viral neuraminidase inhibitors (e.g., oseltamivir).
- **Option C:** Polio is a non-enveloped enterovirus controlled through preventive vaccination, completely unaffected by antibiotics.

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

The _____ in semen facilitate the transport of sperms.

CORE CONCEPT & DERIVATION

Prostaglandins in seminal fluid decrease cervical mucus viscosity and induce reverse peristaltic contractions in the female reproductive tract to assist sperm migration.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Seminal vesicles secrete large quantities of prostaglandins into the ejaculatory duct along with fructose and coagulating enzymes.
- Upon deposition into the vagina, prostaglandins stimulate smooth muscle contractility of the myometrium and oviducts, propelling spermatozoa toward the ampulla for fertilization.

Why other options are incorrect:

- **Option A:** Androgens are steroid sex hormones governing male secondary sex characteristics and gonadal development.
- **Option C:** Oxytocin is a neurohypophysial hormone that stimulates myoepithelial milk ejection and parturition contractions.
- **Option D:** Testosterone is produced by testicular Leydig cells to maintain spermatogenesis, not to mechanically transport sperm in semen.

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

The acidity of urine is neutralized by:

CORE CONCEPT & DERIVATION

Cowper's glands (bulbourethral glands) secrete an alkaline mucus during sexual arousal that neutralizes residual acidic urine in the urethra.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Urine is normally acidic and can damage or kill spermatozoa as they pass through the urethra during ejaculation.
- Prior to ejaculation, the paired bulbourethral glands release a clear, alkaline fluid that coats the urethral lining, neutralizing acidity and lubricating the tract.

Why other options are incorrect:

- **Option B:** The prostate gland produces a slightly alkaline or milky fluid rich in citric acid, acid phosphatase, and fibrinolysin to aid liquefaction.
- **Option C:** Seminal vesicles produce a nutrient-rich, viscous fluid that forms the bulk (approx. 60 percent) of seminal volume.
- **Option D:** The vas deferens is a muscular duct that conveys mature sperm from the epididymis to the ejaculatory duct.

Question #24 Key: (A)BIOLOGY
14. Reproduction

The corpus luteum is essentially formed from:

CORE CONCEPT & DERIVATION

Following ovulation, the collapsed post-ovulatory Graafian follicle transforms under luteinizing hormone stimulation into an endocrine corpus luteum.

Formula / Rule / Reaction:

$$\text{Ruptured Graafian Follicle} \xrightarrow{\text{LH Surge}} \text{Corpus Luteum (secretes progesterone)}$$
Solution:

- After the secondary oocyte is expelled, granulosa and theca interna cells remaining in the ovarian follicle collapse inward.
- Under LH signaling, these cells undergo luteinization, accumulating intracellular lipids and forming a temporary endocrine organ that secretes progesterone.

Why other options are incorrect:

- **Option B:** The ovum is the female gamete that results from fertilization completing meiosis II.
- **Option C:** Oogonia are diploid female stem cells that undergo mitotic proliferation during fetal gestation.
- **Option D:** The oocyte is the gametogenic germ cell expelled during ovulation, leaving the follicular remnants behind.

Question #25 Key: (D)BIOLOGY
14. Reproduction

The outer layer of uterus is called as:

CORE CONCEPT & DERIVATION

The histological wall of the human uterus is organized into three distinct concentric layers: an outer perimetrium, middle myometrium, and inner endometrium.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The perimetrium is the outermost serous tunic covering the uterine fundus and body, composed of simple squamous mesothelium and thin connective tissue.
- It is continuous with the pelvic visceral peritoneum.

Why other options are incorrect:

- **Option A:** The endometrium is the inner mucosal layer containing uterine glands, which undergoes cyclic shedding during menstruation.
- **Option B:** The myometrium is the middle muscular tunic of smooth muscle fibers that generates labor contractions.
- **Option C:** The mesometrium is the broad ligament component attaching the uterus to the pelvic wall, not a wall tunic.

Question #26 Key: (A)BIOLOGY
14. Reproduction

_____ is spread through sexual contact.

CORE CONCEPT & DERIVATION

Gonorrhoea is an obligate sexually transmitted bacterial disease caused by mucosal colonization by the Gram-negative diplococcus *Neisseria gonorrhoeae*.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- *Neisseria gonorrhoeae* adheres via fimbriae and Opa proteins to non-ciliated columnar epithelial cells of the urethra, cervix, and rectum.
- Transmission occurs through direct sexual mucosal contact.

Why other options are incorrect:

- **Option B:** Influenza is an acute respiratory infection transmitted via airborne respiratory droplets.
- **Option C:** Tuberculosis is caused by *Mycobacterium tuberculosis* and spreads by inhaling infectious respiratory droplet nuclei.
- **Option D:** Typhoid fever is an enteric infection spread via contaminated food and water by the fecal-oral route.

Question #27 Key: (C)BIOLOGY
11. Support & Movement

The cells contained in the lacunae of the bone are called:

CORE CONCEPT & DERIVATION

Mature bone cells (osteocytes) reside inside small spaces called lacunae distributed throughout the calcified matrix of compact and spongy bone.

Formula / Rule / Reaction:

Osteoblast $\xrightarrow{\text{Matrix entrapment / Mineralization}}$ Osteocyte (inside lacuna)

Solution:

- Osteoblasts deposit osteoid matrix; as the matrix calcifies, they become enclosed within cavities termed lacunae.
- Once entrapped, they differentiate into mature osteocytes that maintain matrix homeostasis and communicate through canaliculi via gap junctions.

Why other options are incorrect:

- **Option A:** Chondrocytes are mature cartilage cells residing in the lacunae of cartilage, not bone.
- **Option B:** Osteoblasts are active bone-forming cells lining the outer surface of bone tissue, outside the lacunae.
- **Option D:** Osteoclasts are large multinucleated bone-resorbing cells situated in superficial resorption bays (Howship's lacunae).

Question #28 Key: (D)BIOLOGY
11. Support & Movement

The ____ surrounds the muscle fibre of the skeletal muscle.

CORE CONCEPT & DERIVATION

Sarcoplasm is the specialized cytoplasm within a skeletal muscle fiber that surrounds all intracellular myofibrils, glycogen stores, and organelle networks.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- A skeletal muscle fiber contains thousands of contractile myofibrils surrounded by the fluid sarcoplasmic matrix.
- The official KMU answer key awards Option D (Sarcoplasm). Note that the outer plasma membrane enclosing the entire fiber is the sarcolemma, and the external connective tissue layer is the endomysium; among the choices provided, sarcoplasm occupies and envelopes the internal structures within the muscle fiber.

Why other options are incorrect:

- **Option A:** Cytoplasm is the general biological term, whereas skeletal muscle cytoplasm is designated specifically as sarcoplasm.
- **Option B:** Lacunae are microscopic spaces in skeletal bone and cartilage, absent from muscle tissue.
- **Option C:** Myofibrils are the parallel contractile bundles located inside the fiber, bathed within the sarcoplasm.

Question #29 Key: (C)BIOLOGY
11. Support & Movement

What happens to calcium when skeletal muscles recover from contraction?

CORE CONCEPT & DERIVATION

Muscle relaxation requires the active removal of calcium ions from the sarcoplasm back into the sarcoplasmic reticulum lumen by ATP-powered calcium pumps.

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

- Sarcoplasmic/endoplasmic reticulum calcium ATPase (SERCA) pumps use ATP to transport Ca^{2+} back into terminal cisternae against a concentration gradient.
- As sarcoplasmic Ca^{2+} falls below 10^{-7} M, calcium dissociates from troponin C, restoring tropomyosin's steric blockage of actin sites and allowing muscle relaxation.

Why other options are incorrect:

- Option A:** Release of calcium from the sarcoplasmic reticulum into the sarcoplasm initiates cross-bridge cycling and muscle contraction.
- Option B:** Calcium binds to troponin C on thin actin filaments, never to the myosin head.
- Option D:** Skeletal muscle relaxation relies on SERCA re-uptake rather than sarcolemmal sodium-calcium exchangers.

Question #30 Key: (D)BIOLOGY
15. Inheritance / Variation & Genetics

Which of the following blood groups has anti-A and anti-B antibodies in the serum?

CORE CONCEPT & DERIVATION

The ABO blood group system produces reciprocal isoantibodies in serum against whichever A or B oligosaccharide antigens are absent from erythrocyte membranes.

Formula / Rule / Reaction:Group O: No surface A or B agglutinogens $\implies$ Serum contains both Anti-A and Anti-B**Solution:**

- Blood group O individuals lack both A and B surface glycoprotein antigens on their red blood cells.
- Exposure to environmental and dietary oligosaccharides induces IgM and IgG anti-A and anti-B isohemagglutinins in their blood serum.

Why other options are incorrect:

- Option A:** Blood group A individuals possess A antigens on erythrocytes and only anti-B antibodies in serum.
- Option B:** Blood group AB individuals express both A and B antigens on erythrocytes and contain neither anti-A nor anti-B antibodies in serum.
- Option C:** Blood group B individuals express B antigens on erythrocytes and produce only anti-A antibodies in serum.

Question #31 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

What is the primary outcome of crossing over during prophase I of meiosis I?

CORE CONCEPT & DERIVATION

Crossing over in the pachytene stage of meiotic prophase I involves reciprocal non-sister chromatid exchange between homologous chromosomes, generating novel recombinant allele assortments.

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

- Endonuclease cleavage and reciprocal ligation swap genetic segments between non-sister chromatids of a homologous tetrad.
- This breaks parental linkage groups, producing novel combinations of maternal and paternal alleles to increase genetic diversity in gametes.

Why other options are incorrect:

- Option A:** Chromosome duplication occurs prior to meiosis during interphase S-phase, not during prophase I crossing over.
- Option C:** Nonsister chromatids frequently carry different alleles for the same genes, producing recombinant variation rather than identical sets.
- Option D:** Exchange of genetic material between non-homologous chromosomes is an abnormal chromosomal aberration termed reciprocal translocation.

Question #32 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics

The genetic makeup that your parents have transferred to you for your hair color, makes up your...

CORE CONCEPT & DERIVATION

An organism's genotype is the full complement of inherited alleles present at specific genetic loci determining a characteristic.

Formula / Rule / Reaction:

Genotype (Alleles) + Environmental Factors = Phenotype (Expressed Trait)

Solution:

- Parents transmit genetic information in the form of alleles carried on maternal and paternal chromosomes.
- The specific allelic combination inherited for hair pigmentation constitutes the individual's genotype.

Why other options are incorrect:

- Option B:** A karyotype is a photographic map of an individual's complete chromosome set arranged by size and centromere position.
- Option C:** The phenotype is the observable physical expression of the trait (such as black, brown, or blonde hair).
- Option D:** Genotype is the correct genetic term for inherited allelic constitution.

Question #33 Key: (C)BIOLOGY
06. Digestion/Nutrition

Carnivorous plants have evolved mechanisms for trapping and digesting small animals. The produc...

CORE CONCEPT & DERIVATION

Carnivorous plants inhabit acidic, waterlogged soils poor in bioavailable nitrogen, digesting trapped prey to obtain nitrogenous compounds.

Formula / Rule / Reaction:

Prey Proteins $\xrightarrow{\text{Proteolytic Enzymes}}$ Amino Acids $\rightarrow$ Inorganic Nitrogen (Nitrites, Nitrates, Ammonium)

Solution:

- Carnivorous plants are photosynthetic autotrophs that produce their own carbohydrates using sunlight and carbon dioxide.
- Enzymatic hydrolysis of trapped insects provides nitrogenous compounds (such as nitrites and nitrates) required for synthesizing amino acids and nucleic acids.

Why other options are incorrect:

- **Option A:** Carbohydrates are synthesized independently through photosynthetic carbon fixation in the plant's green leaves.
- **Option B:** Lipids are manufactured endogenously by the plant from glyceraldehyde-3-phosphate products.
- **Option D:** Peat bogs and wetland habitats provide abundant moisture; water is not a limiting nutrient supplied by prey.

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

Which is true for an X-linked dominant trait?

CORE CONCEPT & DERIVATION

An affected male carrying an X-linked dominant allele ($X^D Y$) must transmit his single X chromosome to all of his female offspring, causing every daughter to express the condition.

Formula / Rule / Reaction:

$X^D Y \times X^d X^d \rightarrow X^D X^d$ (100% affected females), $X^d Y$ (100% unaffected males)

Solution:

- Fathers contribute their Y chromosome to sons and their X chromosome to daughters.
- Because the mutation is dominant, every daughter who inherits the single X^D chromosome from her affected father will develop the phenotype.

Why other options are incorrect:

- **Option B:** The father transmits his X chromosome to 100 percent of his daughters, not 50 percent.
- **Option C:** A heterozygous affected mother ($X^D X^d$) has a 50 percent chance of transmitting the dominant trait to her sons.
- **Option D:** All female offspring of an affected father inherit the mutated X chromosome and express the trait.

Question #35 Key: (B)BIOLOGY
10. Homeostasis

Malpighian tubules are found in:

CORE CONCEPT & DERIVATION

Malpighian tubules are the primary excretory and osmoregulatory organs of terrestrial insects and certain other arthropods.

Formula / Rule / Reaction:

Hemolymph Wastes $\xrightarrow{\text{Malpighian Tubules}}$ Potassium Urate $\xrightarrow{\text{Hindgut}}$ Solid Uric Acid

Solution:

- In grasshoppers (order Orthoptera), blind-ended Malpighian tubules project from the junction of the midgut and hindgut into the hemocoel.
- They filter nitrogenous waste from the hemolymph and convert it to insoluble, non-toxic uric acid crystals to conserve water.

Why other options are incorrect:

- **Option A:** Earthworms belong to phylum Annelida and use segmentally arranged metanephridia for excretion.
- **Option C:** Leeches are annelids possessing metanephridia for waste removal.
- **Option D:** Slugs belong to phylum Mollusca and use a metanephridial kidney (organ of Bojanus) for excretion.

Question #36 Key: (A)BIOLOGY
10. Homeostasis

Shark belongs to class:

CORE CONCEPT & DERIVATION

Sharks are cartilaginous marine fishes classified under the vertebrate class Chondrichthyes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Class Chondrichthyes comprises jawed vertebrates whose endoskeleton is composed of persistent cartilage rather than true bone.
- Diagnostic features include placoid scales (dermal denticles), lack of an opercular gill cover, ventral mouth position, and absent swim bladder.

Why other options are incorrect:

- **Option B:** Echinodermata is an invertebrate phylum exhibiting pentaradial symmetry and a water vascular system (e.g., sea stars, sea urchins).
- **Option C:** Osteichthyes is the taxonomic class of bony fishes with true bony skeletons, opercula, and swim bladders.
- **Option D:** Urochordata is a subphylum of protochordates (tunicates) possessing a notochord restricted to the larval tail.

Question #37 **Key: (C)**BIOLOGY
10. Homeostasis

Canal system is a characteristic of:

CORE CONCEPT & DERIVATION

The water canal (aquiferous) system is a defining anatomical feature of sponges (phylum Porifera), facilitating feeding, respiration, and excretion.

Formula / Rule / Reaction:

Water Flow: Incurrent Ostia → Mesenchyme / Radial Canals → Spongocoel → Excurrent Osculum

Solution:

- Sponges are sessile parazoans lacking true tissue layers.
- Coordinated beating of flagellated choanocyte cells draws water through surface ostia into an internal canal network, trapping micro-food particles and enabling gas exchange.

Why other options are incorrect:

- **Option A:** Cnidarians possess a blind gastrovascular cavity (coelenteron) with a single oral opening, not a water canal system.
- **Option B:** Protozoans are single-celled eukaryotic organisms without multicellular body canals.
- **Option D:** Segmented worms (annelids) possess a coelomic fluid-filled cavity and a closed circulatory system.

Question #38 **Key: (D)**BIOLOGY
01. Cell

Mantle is the feature of:

CORE CONCEPT & DERIVATION

The mantle (pallium) is a specialized dorsal fold of the body wall unique to mollusks that encloses the visceral mass and secretes the protective shell.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Mussels are bivalve mollusks whose body is enclosed by a two-lobed mantle.
- Glandular epithelium in the outer mantle layer deposits calcium carbonate and conchiolin protein to build and enlarge the protective shell valves.

Why other options are incorrect:

- **Option A:** Annelids have a body wall surrounded by an extracellular collagenous cuticle, lacking a mantle.
- **Option B:** Chordates possess a notochord, dorsal nerve cord, and pharyngeal clefts, without a molluscan mantle.
- **Option C:** Echinoderms have a mesodermal endoskeleton of calcareous ossicles covered by a ciliated epidermis.

Question #39 **Key: (A)**BIOLOGY
04. Bioenergetics

The production of energy is:

CORE CONCEPT & DERIVATION

While aerobic respiration provides a much higher total yield of ATP per glucose molecule, the rate of ATP generation is significantly faster via anaerobic glycolysis.

Formula / Rule / Reaction:

Rate of ATP production: Anaerobic Glycolysis > Aerobic Oxidative Phosphorylation

Solution:

- Anaerobic glycolysis involves only rapid, cytosolic enzymatic reactions without the time-dependent transport and chain kinetics of mitochondria.
- Consequently, anaerobic metabolism can generate ATP up to 100 times faster to meet immediate demands during high-intensity exertion.
- Official KMU answer keys credit Option A based on metabolic kinetics.

Why other options are incorrect:

- **Option B:** Aerobic respiration yields far more total ATP (30 to 32 ATP per glucose), but its multistep mitochondrial reactions proceed at a slower rate.
- **Option C:** The rates of ATP generation differ substantially between cytosolic glycolysis and mitochondrial respiration.
- **Option D:** Respiration is directly defined by metabolic pathways that generate cellular ATP.

Question #40 **Key: (A)**BIOLOGY
04. Bioenergetics

The pathway to the breakdown of glucose, carried out by micro-organisms, is called:

CORE CONCEPT & DERIVATION

Fermentation is an anaerobic pathway utilized by microorganisms to degrade glucose into organic byproducts while regenerating NAD^+ for continued glycolysis.

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

- Lactic acid bacteria (e.g., *Lactobacillus*) degrade glucose via glycolysis and reduce the resulting pyruvate directly to lactate using lactate dehydrogenase.
- Both Option A and Option B represent microbial glucose breakdown pathways; official KMU scoring keys designated Option A (with both fermentative options recognized in post-exam board scrutiny).

Why other options are incorrect:

- **Option B:** Alcoholic fermentation is performed by yeasts, but Option A was designated as the primary keyed choice in the official board rubric.
- **Option C:** Cellular respiration generally designates complete aerobic oxidation of glucose involving electron transport chains and molecular oxygen.
- **Option D:** Valid microbial degradation pathways are listed among the choices.

Question #41 Key: (A)BIOLOGY
01. Cell

Chromosome is typically made up from a combination of:

CORE CONCEPT & DERIVATION

Eukaryotic chromosomes consist of chromatin fibers made of double-stranded DNA complexed with basic histone and non-histone proteins.

Formula / Rule / Reaction:

$$\text{Chromatin} \approx 40\% \text{ DNA} + 60\% \text{ Protein}$$

Solution:

- Nuclear DNA winds around an octamer of core histone proteins (H2A, H2B, H3, H4) to form fundamental nucleosome subunits.
- Histone H1 and non-histone scaffold proteins further condense these nucleosomal beads into 30 nm solenoids and metaphase chromosomes.

Why other options are incorrect:

- **Option B:** Although nascent RNA transcripts associate transiently with active genes, the permanent structural components of chromosomes are DNA and protein.
- **Option C:** Lipids form cellular membrane bilayers and are not components of chromosome structure.
- **Option D:** Chromosomes contain DNA as the genomic repository of genetic information, not RNA.

Question #42 Key: (C)BIOLOGY
01. Cell

Which cytoplasmic organelle make their own proteins?

CORE CONCEPT & DERIVATION

Mitochondria are semi-autonomous organelles possessing their own circular DNA genome and 70S ribosomes, enabling them to synthesize a subset of their own structural proteins.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Derived from an ancestral endosymbiotic alpha-proteobacterium, mitochondria retain circular mtDNA encoding rRNAs, tRNAs, and key hydrophobic subunits of the respiratory chain.
- Matrix 70S ribosomes translate these mitochondrial mRNAs directly within the organelle.

Why other options are incorrect:

- **Option A:** Chromosomes reside in the nucleus (not cytoplasmic organelles) and act as DNA templates for transcription, lacking translational capacity.
- **Option B:** The Golgi apparatus modifies and packages polypeptides received from the rough ER; it lacks ribosomes and DNA.
- **Option D:** The smooth endoplasmic reticulum lacks ribosomes and specializes in lipid biosynthesis, not protein translation.

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

The active movement of mitochondria in the cytoplasm is due to:

CORE CONCEPT & DERIVATION

Cyclosis (cytoplasmic streaming) is the active flow of the fluid cytosol propelled by actin-myosin interactions that circulates organelles throughout the cell.

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

- Myosin motors attached to organelles hydrolyze ATP to walk along actin microfilament tracks anchored beneath the plasma membrane.
- This streaming movement drives the circulation of organelles, including mitochondria, to distribute energy, metabolites, and nutrients.

Why other options are incorrect:

- **Option B:** Endoplasmic streaming movement is a non-standard term; the established biological name is cyclosis.
- **Option C:** The Golgi apparatus processes vesicles and does not generate mechanical motility for cytoplasmic organelles.
- **Option D:** Transfer RNA is an adaptor molecule delivering amino acids to ribosomes during translation.

Question #44 Key: (B)BIOLOGY
12. Nervous Coordination

Which part of the brain is controlling your sense of balance?

CORE CONCEPT & DERIVATION

The cerebellum coordinates equilibrium, muscle tone, and postural stability by integrating vestibular signals from the inner ear with proprioceptive sensory feedback.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Vestibular organs (semicircular canals, saccule, utricle) relay head position and acceleration data to the vestibulocerebellum.
- The cerebellar cortex integrates these inputs with proprioceptive data from skeletal muscle spindles to execute motor corrections that maintain balance.

Why other options are incorrect:

- **Option A:** The amygdala is a limbic structure responsible for emotional regulation, fear responses, and emotional memory consolidation.
- **Option C:** The hippocampus coordinates the consolidation of short-term information into long-term declarative memory and spatial mapping.
- **Option D:** The medulla oblongata houses autonomic centers controlling cardiovascular rate, vasomotor tone, and respiration.

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

The neurotransmitter _____ is hydrolysed by monoamine oxidase:

CORE CONCEPT & DERIVATION

Monoamine oxidase (MAO) is a flavin-containing enzyme localized to the outer mitochondrial membrane that catalyzes the oxidative deamination of catecholamine neurotransmitters.

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

- Adrenaline (epinephrine) is a catecholamine monoamine that is inactivated by monoamine oxidase and catechol-O-methyltransferase.
- Official KMU answer keys credit Option B (Adrenaline). Serotonin (Option D) is also deaminated by MAO-A, but Adrenaline is the primary catecholamine keyed in this examination.

Why other options are incorrect:

- Option A:** Acetylcholine is degraded rapidly into acetate and choline by the enzyme acetylcholinesterase, not by monoamine oxidase.
- Option C:** Glutamate is an amino acid neurotransmitter cleared from synaptic clefts by excitatory amino acid transporters (EAATs).
- Option D:** While serotonin is a substrate of MAO, Adrenaline is the primary catecholamine designated in the board syllabus and official key.

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

Most of the neurons in the CNS are:

CORE CONCEPT & DERIVATION

Multipolar neurons, characterized by a single axon and multiple branching dendrites, comprise over 99 percent of all neurons in the central nervous system.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Multipolar architecture accommodates the convergence of thousands of synaptic inputs onto extensive dendritic trees.
- All interneurons within the brain and spinal cord, along with somatic motor neurons, possess multipolar morphology.

Why other options are incorrect:

- Option A:** Bipolar neurons feature only one axon and one dendrite, restricted to special sensory organs (retina, olfactory epithelium, inner ear).
- Option C:** Pseudo-unipolar neurons possess a single bifurcated axon and are found predominantly in sensory dorsal root ganglia.
- Option D:** Unipolar neurons with a single direct process are characteristic of invertebrate nervous systems and embryonic stages.

Question #47 Key: (D)BIOLOGY
03. Enzymes

How do enzymes enable the conversion of substrates into products?

CORE CONCEPT & DERIVATION

Enzymes accelerate chemical reaction rates by stabilizing the transition state, which substantially lowers the activation energy barrier (E_a).

Formula / Rule / Reaction:

$$k = Ae^{-\frac{E_a}{RT}} \Rightarrow \text{Lower } E_a \text{ increases reaction rate constant } k$$

Solution:

- The enzyme active site positions substrates in optimal geometric orientations and induces strain on target bonds.
- Lowering the required activation energy allows a significantly higher fraction of substrate collisions to proceed to products at physiological temperatures.

Why other options are incorrect:

- Option A:** Catalysts do not alter the chemical equilibrium position (K_{eq}) or standard free energy change (ΔG) of a reaction.
- Option B:** Raising the activation energy would increase the kinetic barrier, decelerating or preventing the reaction.
- Option C:** Enzymes accelerate conversion rates without modifying the underlying quantity or concentration of substrate molecules present.

Question #48 Key: (A)BIOLOGY
16. Evolution

According to Lamarckism, the basis of evolution is:

CORE CONCEPT & DERIVATION

Lamarckism proposed that morphological modifications acquired by an organism through use and disuse during its lifetime are transmitted directly to its progeny.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Jean-Baptiste Lamarck's theory of organic evolution was founded on two principles: the law of use and disuse, and the inheritance of acquired characteristics.
- He argued that physical traits altered by environmental demands could be inherited by subsequent generations.

Why other options are incorrect:

- Option B:** Mutation theory was proposed later by Hugo de Vries following the discovery of discrete genetic variations.
- Option C:** Natural selection is the core evolutionary mechanism developed by Charles Darwin and Alfred Russel Wallace.
- Option D:** Survival of the fittest is a phrase coined by Herbert Spencer and incorporated into Darwinian evolutionary theory.

Question #49 Key: (D)BIOLOGY
16. Evolution

What best describes the hind leg bones seen in the whale?

CORE CONCEPT & DERIVATION

Vestigial structures are anatomical remnants that have lost their original ancestral function through evolutionary reduction.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Modern baleen and toothed whales possess internal pelvis and femur bone remnants embedded within their abdominal wall muscles.
- These bones are non-functional remnants of hind limbs inherited from four-legged terrestrial mammalian ancestors (such as *Pakicetus* and *Ambulocetus*).

Why other options are incorrect:

- **Option A:** The hind leg bones are internal skeletal remnants and not analogous swimming structures like fish fins.
- **Option B:** These bones are present inside living whales today, not merely preserved as extinct fossils.
- **Option C:** Tetrapod forelimbs (not hind leg remnants) share homology with bat wings.

Question #50 Key: (C)BIOLOGY
06. Digestion/Nutrition

Which is true about the cells found in gastric glands lining the stomach wall?

CORE CONCEPT & DERIVATION

Gastric mucosa contains specialized glandular epithelial cells: mucous cells (secreting mucin), parietal cells (secreting HCl and intrinsic factor), and chief cells (secreting pepsinogen).

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Mucous neck cells and surface epithelial cells secrete mucin glycoproteins and bicarbonate ions.
- Mucin forms an insoluble protective gel layer that shields the stomach lining from autolysis by hydrochloric acid and active pepsin.

Why other options are incorrect:

- **Option A:** Chief (zymogenic) cells synthesize and secrete pepsinogen; gastrin is secreted by enteroendocrine G-cells.
- **Option B:** Intrinsic factor is synthesized and released by oxyntic (parietal) cells, not by endocrine hormone cells.
- **Option D:** Parietal cells secrete hydrochloric acid and intrinsic factor; pepsinogen is secreted by chief cells.

Question #51 Key: (C)BIOLOGY
08. Immunity

What directly triggers the activation of natural killer cells?

CORE CONCEPT & DERIVATION

Natural killer (NK) cells are cytotoxic innate lymphocytes whose antitumor and antiviral activities are directly stimulated by cytokines, notably type I interferons.

Formula / Rule / Reaction:Virus-Infected Cell → Interferons (IFN- α/β) → Activation of NK Cells**Solution:**

- When host cells are infected by viruses, they synthesize and secrete type I interferons (interferon-alpha and interferon-beta).
- These interferons bind to specific cell-surface receptors on natural killer cells, triggering their cytotoxic degranulation to release perforins and granzymes.

Why other options are incorrect:

- **Option A:** Free radicals are reactive oxygen species that induce oxidative damage to biomolecules rather than acting as physiological receptor ligands for NK activation.
- **Option B:** Hydrogen peroxide is an oxidative byproduct used by phagocytes within phagolysosomes, not a signaling trigger for NK activation.
- **Option D:** Molecular oxygen is required for aerobic respiration and does not directly activate natural killer cells.

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

Which of the following is NOT true about plasmids found in streptococci?

CORE CONCEPT & DERIVATION

Plasmids are dispensable, extrachromosomal genetic elements that replicate independently, whereas the bacterial chromosome relies solely on its own origin of replication.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Plasmids replicate independently via their own *oriV* sites and do not govern or support chromosomal DNA replication.
- The bacterial chromosome contains its own origin of replication (*oriC*) and operates entirely independently of plasmid presence.

Why other options are incorrect:

- **Option A:** Plasmids range from a few to several hundred kilobases and consistently encode far fewer genes than the primary circular chromosome.
- **Option B:** Plasmids replicate autonomously using host cell machinery without needing simultaneous chromosomal replication.
- **Option C:** Plasmids are non-chromosomal genetic elements that often carry accessory traits such as antibiotic resistance.

Question #53 Key: (C)BIOLOGY
10. Homeostasis

Which of the following bacteria produces endospores?

CORE CONCEPT & DERIVATION

Endospores are dormant, highly resistant structures produced almost exclusively by certain genera of Gram-positive bacteria during severe nutrient depletion.

Formula / Rule / Reaction:

Vegetative Gram-Positive Cell $\xrightarrow{\text{Nutrient Deprivation / Sporulation}}$ Resistant Endospore

Solution:

- Endospore formation is a specialized developmental program characteristic of low-G+C Gram-positive rods, notably *Bacillus* and *Clostridium* species.
- The endospore coat contains dipicolinic acid complexed with calcium ions, providing extreme resistance to desiccation, heat, and ultraviolet radiation.

Why other options are incorrect:

- Option A:** Standard Gram-negative bacteria do not produce true heat-resistant endospores.
- Option B:** Gram-negative bacteria typically respond to starvation via stationary-phase physiological adjustments rather than endospore morphogenesis.
- Option D:** Mycobacteria are acid-fast actinobacteria that do not produce classic bacterial endospores.

Question #54 Key: (A)BIOLOGY
17. Biotechnology

_____ is used in the production of Humulin?

CORE CONCEPT & DERIVATION

Humulin (recombinant human insulin) is manufactured commercially using genetically engineered bacteria transformed with human insulin-coding DNA sequences.

Formula / Rule / Reaction:

Human Proinsulin / A & B Chain cDNA + pBR322 / Expression Vector $\xrightarrow{\text{Transformation}}$ Recombinant *Escherichia coli*

Solution:

- Synthetic genes corresponding to the A and B polypeptide chains of human insulin are inserted into expression plasmids in *Escherichia coli*.
- The cultured bacteria express the recombinant proteins, which are extracted, purified, and joined chemically via disulfide bonds to form active Humulin.

Why other options are incorrect:

- Option B:** Although some yeast species (*Saccharomyces cerevisiae*) produce insulin analogs, Humulin was originally and predominantly developed using *E. coli* bacteria.
- Option C:** Protozoans are not utilized as host systems for industrial-scale recombinant insulin synthesis.
- Option D:** Viruses lack independent biosynthetic machinery and function solely as vectors, not production hosts.

Question #55 Key: (C)BIOLOGY
11. Support & Movement

Which of the following does NOT relate to smooth muscles?

CORE CONCEPT & DERIVATION

The muscular wall of the heart consists exclusively of specialized cardiac muscle tissue, whereas smooth muscle lines the walls of hollow visceral organs and vascular channels.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The myocardium is composed of striated, branched, uninucleate cardiac myocytes joined by intercalated discs.
- Smooth muscle is found within the walls of the gastrointestinal tract, urinary bladder, bronchi, and blood vessels, not the heart wall.

Why other options are incorrect:

- Option A:** Smooth muscle contraction is regulated involuntarily by sympathetic and parasympathetic divisions of the autonomic nervous system.
- Option B:** Individual smooth muscle myocytes are fusiform and spindle-shaped with central, elongated nuclei.
- Option D:** Smooth muscles lack sarcomeric registration of thick and thin filaments, showing an unstriated (smooth) microscopic appearance.

Question #56 Key: (D)BIOLOGY
15. Inheritance / Variation & Genetics

Which term best describes an organism's physical characteristic?

CORE CONCEPT & DERIVATION

A trait is any distinct, observable physical, physiological, or behavioral property manifested by an organism.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- A trait represents an identifiable morphological or functional attribute (such as height, petal coloration, or seed shape).
- The collection of expressed traits in an individual comprises its phenotype.

Why other options are incorrect:

- Option A:** An allele is a specific alternative sequence variant of a gene located at a designated chromosomal locus.
- Option B:** The genetic code is the degenerate set of nucleotide triplets (codons) specifying amino acids during translation.
- Option C:** The genotype denotes the internal allelic makeup inherited by an organism.

Question #57 **Key: (C)**BIOLOGY
07. Circulation / Transport

What will happen with the addition of salt to water?

CORE CONCEPT & DERIVATION

In provincial textbook curricula, osmotic potential is defined as the measure of the tendency of a solution to withdraw water via osmosis, which increases in magnitude as solute concentration rises.

Formula / Rule / Reaction:

Solute Addition $\Rightarrow$ $\uparrow$ Osmotic Pressure / Potential (Textbook definition), $\downarrow \Psi_w$ (Water Potential)

Solution:

- Dissolving sodium chloride in water yields hydrated ions that restrict free water molecule mobility.
- In regional textbooks, this enhanced capacity to draw in water across a semipermeable membrane is designated as an increase in osmotic potential, corresponding to a decrease in water potential (Ψ_w).

Why other options are incorrect:

- **Option A:** Water potential of pure water is zero; adding salt lowers free energy, causing water potential to decrease (become more negative).
- **Option B:** Water potential changes continuously with the addition of any non-volatile solute.
- **Option D:** Osmotic parameters vary proportionally with changes in solute molality.

Question #58 **Key: (B)**BIOLOGY
05. Acellular Life

Which of the following is NOT true about viruses?

CORE CONCEPT & DERIVATION

Viruses are obligate intracellular molecular parasites that possess no independent metabolic machinery and cannot replicate outside a permissive host cell.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Viruses lack ribosomes, metabolic enzymes, and ATP-generating pathways.
- They cannot replicate independently, relying entirely on hijacking host cellular translation and transcription systems.

Why other options are incorrect:

- **Option A:** Many virus families possess DNA genomes, including Adenoviruses, Herpesviruses, and Poxviruses.
- **Option C:** Bacteriophages are specialized viruses that infect and lyse bacterial cells.
- **Option D:** Viruses are non-cellular (sub-cellular) assemblies composed of nucleic acid encased in a capsid.

Question #59 **Key: (B)**BIOLOGY
05. Acellular Life

The genetic material of _____ is bound by a lipid membrane?

CORE CONCEPT & DERIVATION

Enveloped viruses enclose their nucleocapsid within an outer host-derived lipid bilayer membrane embedded with viral glycoproteins.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The influenza (flu) virus is an enveloped orthomyxovirus.
- Its segmented negative-sense RNA genome is housed in a core surrounded by a host-derived lipid envelope containing hemagglutinin and neuraminidase spikes.

Why other options are incorrect:

- **Option A:** Enteroviruses are naked (non-enveloped) positive-sense single-stranded RNA picornaviruses lacking a lipid membrane.
- **Option C:** Hepatitis A virus is a non-enveloped picornavirus with a naked protein capsid.
- **Option D:** Poliovirus is a non-enveloped icosahedral picornavirus resistant to lipid-dissolving solvents.

Question #60 **Key: (B)**BIOLOGY
05. Acellular Life

Viruses can NOT _____.

CORE CONCEPT & DERIVATION

Viruses possess no cytoplasm, metabolic pathways, or nutritional turnover, making homeostatic processes like metabolic excretion biologically impossible.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Excretion requires active cellular metabolic turnover to produce and expel chemical waste products.
- Because viruses are acellular assemblies without metabolic processes, they do not produce wastes or perform excretion.

Why other options are incorrect:

- **Option A:** Viruses can be purified and precipitated into crystalline arrays, as demonstrated by Wendell Stanley with Tobacco Mosaic Virus.
- **Option C:** Bacteriophages specifically infect and replicate within bacterial hosts.
- **Option D:** Viral genomes undergo nucleotide substitutions, insertions, and deletions, giving them high mutation rates.

Question #61 Key: (C)BIOLOGY
05. Acellular Life

Where are the enzymes required for the replication of HIV virus located?

CORE CONCEPT & DERIVATION

Retroviral replication enzymes are pre-packaged within the inner protein capsid core alongside the viral genomic RNA.

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

- The conical capsid core of HIV (formed by the p24 protein) encloses two identical copies of positive-sense single-stranded RNA.
- Crucial replication enzymes, including reverse transcriptase, integrase, and protease, are located directly inside this capsid chamber to initiate reverse transcription upon host entry.

Why other options are incorrect:

- **Option A:** Protein spikes consist of envelope glycoproteins (gp120 and gp41) that mediate receptor binding and membrane fusion, lacking enzymatic roles.
- **Option B:** The matrix shell (p17) surrounds the core but does not house the replication enzymes.
- **Option D:** Free replication enzymes are not situated exterior to the protecting capsid shell.

Question #62 Key: (C)BIOLOGY
04. Bioenergetics

The process of ATP synthesis through a combination of electrochemical and osmotic events is known...

CORE CONCEPT & DERIVATION

Oxidative phosphorylation couples electron transfer through respiratory complexes with the establishment of a proton electrochemical gradient that drives ATP synthesis via chemiosmosis.

Formula / Rule / Reaction:

$$\Delta p = \Delta \psi - \frac{2.303RT}{F} \Delta \text{pH} \implies \text{Proton Motive Force drives } F_0F_1\text{-ATP Synthase}$$

Solution:

- Electrons derived from NADH and FADH₂ travel through electron transport complexes, pumping protons across the inner mitochondrial membrane into the intermembrane space.
- The resulting electrochemical and osmotic proton gradient powers the rotational catalysis of F₀F₁-ATP synthase, producing ATP from ADP and inorganic phosphate.

Why other options are incorrect:

- **Option A:** Fermentation synthesizes ATP exclusively via substrate-level phosphorylation under anaerobic conditions without an electrochemical gradient.
- **Option B:** Glycolysis produces ATP through cytoplasmic substrate-level phosphorylation reactions mediated by kinases.
- **Option D:** Pyruvate decarboxylation to acetyl-CoA reduces NAD⁺ without directly driving chemiosmotic ATP synthesis.

Question #63 Key: (D)BIOLOGY
03. Enzymes

Optimum pH for pancreatic lipase is:

CORE CONCEPT & DERIVATION

Pancreatic lipase operates in the alkaline environment of the duodenum maintained by biliary and pancreatic bicarbonate secretions, exhibiting maximum activity at pH 8.0.

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

- Pancreatic juice contains high concentrations of sodium bicarbonate to neutralize acidic gastric chyme entering the small intestine.
- This creates an alkaline luminal milieu near pH 7.5 to 8.0, matching the catalytic optimum of pancreatic lipase.

Why other options are incorrect:

- **Option A:** A pH of 2 is the acidic optimum for gastric pepsin, which denatures pancreatic lipase.
- **Option B:** A pH of 4 is overly acidic and causes irreversible loss of lipase catalytic function.
- **Option C:** A pH of 6 is slightly acidic, yielding low catalytic efficiency compared to the alkaline optimum.

Question #64 Key: (D)BIOLOGY
02. Biomolecules

Sugarcane contains _____.

CORE CONCEPT & DERIVATION

Sucrose is a non-reducing disaccharide composed of glucose and fructose that serves as the principal transport and storage carbohydrate in sugarcane.

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

- Sugarcane (*Saccharum officinarum*) synthesizes sucrose via photosynthesis in its foliage.
- Sucrose is translocated through the phloem and accumulates in the parenchymatous stem pith at concentrations up to 15 to 20 percent of fresh stem weight.

Why other options are incorrect:

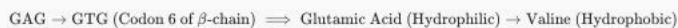
- **Option A:** Free fructose occurs in honey and ripe fruits, but forms only one subunit of the stored sucrose dimer in sugarcane.
- **Option B:** Free glucose exists in small metabolic amounts rather than serving as the major accumulated sugar.
- **Option C:** Ribose is an aldopentose sugar incorporated into nucleotides and RNA, not an agricultural storage disaccharide.

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

Sickle cell anaemia results from:

CORE CONCEPT & DERIVATION

Sickle cell anaemia is a monogenic autosomal recessive hemoglobinopathy caused by a missense point mutation in the beta-globin gene.

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

- A point mutation replaces hydrophilic glutamic acid with hydrophobic valine at position 6 of the beta-globin polypeptide chain.
- Under low oxygen tension, this substitution creates a sticky hydrophobic patch that leads to polymer formation and characteristic red cell sickling.

Why other options are incorrect:

- **Option A:** Decreased oxygen-carrying capacity is a physiological symptom of the disorder, not its molecular cause.
- **Option B:** Inter-chain disulfide or covalent linkages do not cause sickle hemoglobin polymerization.
- **Option D:** Sickle cell anaemia is an inherited genetic condition and is not caused by infectious agents.

Question #66 Key: (A)BIOLOGY
02. Biomolecules

Which is INCORRECT about globular proteins?

CORE CONCEPT & DERIVATION

Globular proteins fold into compact spherical shapes with hydrophilic residues on their exterior, making them water-soluble, whereas hair is composed of insoluble fibrous keratin.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Hair, nails, and horns are composed of alpha-keratin, a classic fibrous structural protein held together by disulfide bridges and hydrophobic interactions.
- Alpha-keratin forms insoluble elongated filaments rather than soluble globular conformations.

Why other options are incorrect:

- **Option B:** Globular proteins fold their tertiary structure into compact, roughly spherical or ellipsoidal geometries.
- **Option C:** All globular proteins are polymers composed of one or more polypeptide chains.
- **Option D:** Globular proteins orient polar and charged residues toward the aqueous solvent, conferring water solubility.

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

What is the ester of fatty acids and long chain alcohol called?

CORE CONCEPT & DERIVATION

Waxes are simple lipid esters formed by the condensation of long-chain fatty acids with long-chain monohydric alcohols.

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

- Waxes contain a fatty acid chain (typically 14 to 36 carbons) linked to a long-chain alcohol (typically 16 to 30 carbons) via an ester bond.
- This structure produces water-repellent coatings on plant leaves, fruits, and animal pelts.

Why other options are incorrect:

- **Option A:** Acylglycerols are esters formed between fatty acids and glycerol (a trihydric alcohol), not long-chain monohydric alcohols.
- **Option B:** Glycerol is a three-carbon triol (propane-1,2,3-triol), which is an alcohol rather than an ester.
- **Option C:** Phospholipids contain a glycerol or sphingosine backbone joined to fatty acids and a phosphate head group.

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

Lipids, which do not contain fatty acid are:

CORE CONCEPT & DERIVATION

Steroids are non-saponifiable lipids built around a cyclopentanoperhydrophenanthrene ring system, containing no fatty acid moieties.

Formula / Rule / Reaction:

Steroid Core: 17 Carbon Atoms arranged in 4 fused rings (three 6-membered, one 5-membered)

Solution:

- Unlike acylglycerols, phospholipids, and waxes, steroids do not contain fatty acid chains or ester linkages.
- Steroids are synthesized from isoprenoid units via squalene cyclization, forming fused ring structures like cholesterol and steroid hormones.

Why other options are incorrect:

- **Option A:** Neutral lipids (triacylglycerols) consist of three fatty acid molecules esterified to a glycerol backbone.
- **Option B:** Phosphatidic acid is a diacylglycerol with two ester-linked fatty acids and a phosphate group.
- **Option D:** Waxes contain long-chain fatty acids esterified to long-chain monohydric alcohols.

Question #69 Key: (D)

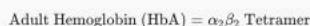
CHEMISTRY
19. Macromolecules / Biochemistry

Protein present in haemoglobin has _____ structure.

CORE CONCEPT & DERIVATION

Quaternary protein structure describes the spatial assembly and non-covalent association of multiple independent polypeptide subunits into a functional oligomeric complex.

Formula / Rule / Reaction:



Solution:

- Adult hemoglobin is a heterotetrameric globular protein composed of two alpha-globin and two beta-globin subunits.
- Each subunit contains its own folded tertiary structure with an embedded heme group, stabilized into a functional quaternary tetramer by salt bridges and hydrophobic contacts.

Why other options are incorrect:

- **Option A:** Primary structure refers strictly to the linear sequence of amino acids linked by peptide bonds.
- **Option B:** Secondary structure comprises localized spatial patterns like alpha-helices and beta-pleated sheets.
- **Option C:** Tertiary structure describes the complete 3D folding of a single polypeptide chain (e.g., myoglobin).

Question #70 Key: (C)

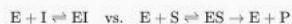
CHEMISTRY
19. Macromolecules / Biochemistry

In competitive inhibition, the inhibitor:

CORE CONCEPT & DERIVATION

A competitive inhibitor structurally resembles the normal substrate, directly competing with it for occupancy of the enzyme's catalytic active site.

Formula / Rule / Reaction:



Solution:

- Because the inhibitor and substrate share structural homology, both recognize the same active-site binding pocket.
- Substrate and inhibitor compete for free enzyme active sites, and increasing substrate concentration overcomes the inhibition.

Why other options are incorrect:

- **Option A:** Competitive inhibitors bind directly to the free enzyme, not to the substrate.
- **Option B:** The inhibitor binds to the enzyme to block the substrate; it does not compete with the enzyme itself.
- **Option D:** Competitive inhibition is reversible and mediated by non-covalent interactions.

Question #71 Key: (A)

CHEMISTRY
03. Chemical Bonding

Which one of the following molecules has a zero-dipole moment?

CORE CONCEPT & DERIVATION

A molecule exhibits a net dipole moment of zero when its individual polar bond vectors cancel completely due to symmetrical molecular geometry.

Formula / Rule / Reaction:

$$\vec{\mu}_{\text{net}} = \sum \vec{\mu}_i = 0 \quad (\text{Trigonal Planar Geometry, } D_{3h})$$

Solution:

- Boron trifluoride (BF₃) possesses an sp²-hybridized boron atom forming three B-F bonds oriented at 120° in a trigonal planar arrangement.
- The three equal B-F bond dipole vectors point toward the corners of an equilateral triangle, canceling out to produce $\mu = 0$ D.

Why other options are incorrect:

- **Option B:** NF₃ has a trigonal pyramidal geometry with an unshared electron pair, yielding a net dipole moment of $\mu \approx 0.24$ D.
- **Option C:** NH₃ is trigonal pyramidal with a lone pair reinforcing bond dipoles, giving $\mu \approx 1.47$ D.
- **Option D:** H₂O has an asymmetric bent geometry with two lone pairs, resulting in $\mu \approx 1.85$ D.

Question #72 Key: (D)

CHEMISTRY
03. Chemical Bonding

The unhybridized p orbital in [Formula] hybridization is:

CORE CONCEPT & DERIVATION

In sp² hybridization, three hybrid orbitals lie within a single plane at 120° angles, while the remaining unhybridized p orbital is oriented at right angles to that plane.

Formula / Rule / Reaction:



Solution:

- Mixing one s and two p orbitals produces three sp² hybrid orbitals lying in the xy-plane.
- The unhybridized p_z orbital consists of two lobes oriented along the z-axis, perpendicular (90°) to the hybrid orbital plane.

Why other options are incorrect:

- **Option A:** The unhybridized p orbital cannot lie in the hybrid plane because its nodal plane coincides with that plane.
- **Option B:** While it extends out of the plane, Option D precisely defines its orthogonal (perpendicular) orientation.
- **Option C:** The lobes of the unhybridized p orbital run perpendicular, not parallel, to the coplanar hybrid orbitals.

Question #73 Key: (D)

CHEMISTRY
04. Gases

760 torr is equal to ____ Pascal:

CORE CONCEPT & DERIVATION

Standard atmospheric pressure is defined as exactly 760 torr, which corresponds to 101325 Pascals in SI metric units.

Formula / Rule / Reaction:

$$1 \text{ atm} = 760 \text{ torr} = 760 \text{ mmHg} = 101325 \text{ N/m}^2 = 101325 \text{ Pa} = 101.325 \text{ kPa}$$

Solution:

- One torr is defined as the pressure exerted by a 1 mm column of mercury under standard conditions.
- Multiplying column height by mercury density and standard gravity yields:
- $P = \rho gh = (13595.1 \text{ kg/m}^3)(9.80665 \text{ m/s}^2)(0.760 \text{ m}) = 101325 \text{ Pa}$

Why other options are incorrect:

- Option A:** 1 Pascal represents 1 N/m^2 , which equals approximately 7.5×10^{-3} torr.
- Option B:** 76 corresponds to the height of a mercury barometer in centimeters, not a Pascal value.
- Option C:** 760 is the pressure expressed in torr or millimeters of mercury, not Pascals.

Question #74 Key: (D)

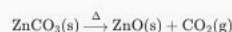
CHEMISTRY
01. Stoichiometry

How many grams of [Formula] can be produced by thermally decomposing 10 moles of [Formula]?

CORE CONCEPT & DERIVATION

Thermal decomposition of metal carbonates follows stoichiometric ratios, yielding metal oxide and carbon dioxide gas.

Formula / Rule / Reaction:



Solution:

- From the balanced chemical equation, 1 mole of ZnCO_3 produces 1 mole of CO_2 .
- Therefore, 10 moles of ZnCO_3 produce 10 moles of CO_2 .
- Using the molar mass of CO_2 (44.01 g/mol):
- $\text{Mass} = n \times M = 10 \text{ mol} \times 44.01 \text{ g/mol} = 440.1 \text{ g} \approx 440 \text{ g}$

Why other options are incorrect:

- Option A:** 320 g corresponds to an incorrect molar yield or calculation error.
- Option B:** 360 g corresponds to approximately 8.18 moles of carbon dioxide.
- Option C:** 400 g fails to account for the full molar mass of carbon dioxide (44 g/mol).

Question #75 Key: (D)

CHEMISTRY
05. Liquids

Molar heat of vaporization of water is:

CORE CONCEPT & DERIVATION

The molar enthalpy of vaporization (ΔH_{vap}) is the heat energy required to transform one mole of liquid into vapor at its normal boiling point under standard pressure.

Formula / Rule / Reaction:



Solution:

- Water molecules are held together by an extensive three-dimensional network of intermolecular hydrogen bonds.
- Overcoming these hydrogen bonds during vaporization requires 40.7 kilojoules per mole of water molecules.

Why other options are incorrect:

- Option A:** The calorie value is approximately 9.72 kcal/mol; 40.7 cal/mol is far too small.
- Option B:** The energy requirement is in kilojoules; 40.7 J/mol is smaller by a factor of 1000.
- Option C:** 40.7 kcal/mol is more than four times higher than the true thermodynamic value (1 cal = 4.184 J).

Question #76 Key: (D)

CHEMISTRY
05. Liquids

Distillation under very reduced pressure is ____ distillation:

CORE CONCEPT & DERIVATION

Vacuum distillation is the process of distilling liquids at lowered external pressure, allowing high-boiling or heat-sensitive compounds to vaporize at reduced temperatures.

Formula / Rule / Reaction:

$$P_{\text{ext}} = P_{\text{vap}} \implies \text{Lowering } P_{\text{ext}} \text{ lowers normal boiling point } T_b$$

Solution:

- Liquids boil when their vapor pressure matches the surrounding ambient pressure.
- Lowering the pressure inside the apparatus via a vacuum pump enables distillation well below normal boiling points, preventing thermal decomposition.

Why other options are incorrect:

- Option A:** Destructive distillation involves heating complex organic materials (like coal) to extreme temperatures in the absence of air to induce pyrolysis.
- Option B:** Fractional distillation separates volatile components based on differences in boiling points using a fractionating column at atmospheric pressure.
- Option C:** Steam distillation co-distills water-immiscible, temperature-sensitive organic compounds using steam injection.

Question #77 Key: (C)

CHEMISTRY
06. Solids

The example of a metallic solid is:

CORE CONCEPT & DERIVATION

Metallic solids are crystalline arrays of positive metal ions (cations) held together within a delocalized sea of valence electrons via metallic bonds.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Copper (Cu) crystallizes in a face-centered cubic metallic lattice held together by delocalized electron bonding.
- This structure gives copper its high electrical conductivity, malleability, and ductility.

Why other options are incorrect:

- **Option A:** Boron is a metalloid that forms complex covalent network solids composed of B₁₂ icosahedra.
- **Option B:** Carbon forms covalent network crystals, such as tetrahedral diamond or planar graphite.
- **Option D:** Silicon forms a covalent network solid possessing a diamond cubic crystal structure.

Question #78 Key: (B)

CHEMISTRY
06. Solids

When a crystalline substance conducts current in one direction but not through other directions...

CORE CONCEPT & DERIVATION

Anisotropy is the physical property of a crystalline solid whereby its physical properties vary depending on the crystallographic direction of measurement.

Formula / Rule / Reaction:

$$\text{Physical Property (Direction } x) \neq \text{Physical Property (Direction } y)$$

Solution:

- Crystals feature orderly, regular arrangements of constituent particles whose spacing and bonding vary along different crystallographic axes.
- In graphite, for example, electrons conduct readily parallel to hexagonal carbon sheets but encounter high electrical resistance perpendicular to the layers.

Why other options are incorrect:

- **Option A:** Allotropy describes an element's ability to exist in two or more distinct physical structural forms in the same state (e.g., diamond and graphite).
- **Option C:** Isomorphism is the occurrence of two distinct chemical compounds in identical crystal shapes.
- **Option D:** Polymorphism is the capacity of a specific chemical compound to crystallize in more than one distinct crystalline form.

Question #79 Key: (D)

CHEMISTRY
07. Equilibrium

Forward reaction is the one that:

CORE CONCEPT & DERIVATION

By chemical convention, the forward reaction in a reversible process converts reactants located on the left-hand side of the equation into products on the right-hand side.

Formula / Rule / Reaction:



Solution:

- A chemical equation is balanced with starting reactants written on the left and resulting products on the right.
- The forward pathway represents left-to-right mass transfer, starting at a maximum rate when reactant concentrations are highest and decreasing over time.

Why other options are incorrect:

- **Option A:** The forward reaction proceeds at its fastest rate at time zero because initial reactant concentrations are at their peak.
- **Option B:** The reaction that regenerates original reactants from products is the reverse (backward) reaction.
- **Option C:** The forward reaction decelerates gradually over time as reactants are consumed; the reverse reaction speeds up from zero until equilibrium is reached.

Question #80 Key: (B)

CHEMISTRY
01. Stoichiometry

How many moles of [Formula] are produced from [Formula] of [Formula], according to the neutral...

CORE CONCEPT & DERIVATION

Stoichiometric molar ratios from balanced neutralization equations allow determination of product moles from reactant mass.

Formula / Rule / Reaction:

$$n = \frac{\text{Mass (g)}}{\text{Molar Mass (g/mol)}} = \frac{m}{M}$$

Solution:

- Calculate the molar mass of hydrochloric acid: $M_{\text{HCl}} = 1.008 + 35.45 = 36.46 \text{ g/mol}$.
- Calculate the moles of HCl reacted:

$$n_{\text{HCl}} = \frac{16.5 \text{ g}}{36.46 \text{ g/mol}} \approx 0.4525 \text{ mol}$$

- From the equation stoichiometry, the ratio of HCl to NaCl is 1:1, yielding 0.452 mol of NaCl.

Why other options are incorrect:

- **Option A:** 0.252 mol would result from using an incorrect molar mass near 65.5 g/mol.
- **Option C:** 0.652 mol is an arithmetic overestimation.
- **Option D:** 0.852 mol corresponds to approximately double the correct stoichiometric yield.

Question #81 Key: (B)

CHEMISTRY
07. Equilibrium

In the production of [Formula] from [Formula] and oxygen, the yield of [Formula] is increased b...

CORE CONCEPT & DERIVATION

According to Le Chatelier's principle, introducing additional reactant into a system at equilibrium shifts the position of equilibrium toward the product side.

Formula / Rule / Reaction:



Solution:

- Increasing the concentration or partial pressure of sulfur dioxide (SO_2) causes the reaction quotient Q_c to become less than K_c .
- The forward reaction accelerates to consume excess SO_2 , shifting equilibrium to the right and increasing the yield of SO_3 .

Why other options are incorrect:

- Option A:** Adding a catalyst (such as V_2O_5) accelerates the forward and reverse rates equally without altering equilibrium yield.
- Option C:** Because the forward reaction is exothermic, increasing temperature shifts equilibrium to the left, decreasing SO_3 yield.
- Option D:** Removing a reactant (O_2) shifts the equilibrium to the left, reducing product formation.

Question #82 Key: (B)

CHEMISTRY
07. Equilibrium

Consider [Formula]. The optimum temperature ([Formula]) to produce ammonia is:

CORE CONCEPT & DERIVATION

The industrial Haber process balances the thermodynamic yield of an exothermic reaction with the kinetic activation barrier of iron catalysts using a compromised optimum temperature around 400 to 450°C.

Formula / Rule / Reaction:

Exothermic Synthesis: Low T favors high yield, High T provides acceptable rate

Solution:

- At low temperatures, chemical kinetics are unacceptably slow due to the high activation energy of breaking the $\text{N} \equiv \text{N}$ triple bond.
- At excessive temperatures, equilibrium shifts strongly toward reactants. A temperature of 450°C provides an optimal compromise between yield and reaction rate.

Why other options are incorrect:

- Option A:** At 0°C, reactant molecules lack the kinetic energy to overcome the activation barrier, yielding a negligible reaction rate.
- Option C:** At 5000°C, the equilibrium shifts completely to the left, thermally decomposing ammonia into its elements.
- Option D:** Constant temperature is a thermodynamic condition rather than a specific operational value.

Question #83 Key: (B)

CHEMISTRY
07. Equilibrium

The unit of [Formula] for the system [Formula] is:

CORE CONCEPT & DERIVATION

The units of an equilibrium constant K_c depend on the difference between the sum of product stoichiometric coefficients and reactant stoichiometric coefficients (Δn).

Formula / Rule / Reaction:

$$K_c = \frac{[\text{PCl}_3][\text{Cl}_2]}{[\text{PCl}_5]}, \quad \text{Unit} = (\text{mol} \cdot \text{dm}^{-3})^{\Delta n} = (\text{mol} \cdot \text{dm}^{-3})^{(1+1)-1}$$

Solution:

- Substitute molar concentration units into the equilibrium expression:

$$\text{Unit of } K_c = \frac{(\text{mol}/\text{dm}^3)(\text{mol}/\text{dm}^3)}{\text{mol}/\text{dm}^3} = \text{mol}/\text{dm}^3$$

Why other options are incorrect:

- Option A:** dm^3/mol is the unit when $\Delta n = -1$ (e.g., in dimerizations).
- Option C:** mol/dm^6 is dimensionally inconsistent with chemical equilibrium formulations.
- Option D:** mol^2/dm^6 is the unit for systems with $\Delta n = +2$.

Question #84 Key: (C)

CHEMISTRY
08. Reaction Kinetics

For a first order reaction [Formula], the rate constant is [Formula]. Calculate rate of the r...

CORE CONCEPT & DERIVATION

For a first-order chemical reaction, the instantaneous reaction rate is directly proportional to the first power of reactant concentration.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^1$$

Solution:

- Substitute the given values into the first-order rate law:

$$\text{Rate} = (0.0458 \text{ s}^{-1}) \times (0.35 \text{ mol dm}^{-3}) = 0.01603 \text{ mol dm}^{-3} \text{ s}^{-1}$$

- Rounding to two significant figures yields $0.016 \text{ mol dm}^{-3} \text{ s}^{-1}$.

Why other options are incorrect:

- Option A:** 0.012 would result from a smaller rate constant near 0.034 s^{-1} .
- Option B:** 0.014 underestimates the product of 0.0458×0.35 .
- Option D:** 0.018 would require a reactant concentration near $0.393 \text{ mol dm}^{-3}$.

Question #85 Key: (D)

CHEMISTRY
08. Reaction Kinetics

A reaction is first order with respect to A and second order with respect to B, the rate equati...

CORE CONCEPT & DERIVATION

In chemical kinetics, the differential rate law expresses the reaction rate as the product of the rate constant and reactant concentrations raised to their respective reaction orders.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^x[B]^y \quad (x = 1, y = 2)$$

Solution:

- The order with respect to reactant A is 1, so the exponent on [A] is 1.
- The order with respect to reactant B is 2, so the exponent on [B] is 2.
- Combining these terms yields the overall third-order rate equation: $\text{Rate} = k[A][B]^2$.

Why other options are incorrect:

- Option A:** Represents a reaction that is first order in A and zero order in B.
- Option B:** Represents a reaction that is first order in both A and B (overall second order).
- Option C:** Reverses the reaction orders, making it second order in A and first order in B.

Question #86 Key: (C)

CHEMISTRY
01. Stoichiometry

What mass of aluminium oxide ([Formula]) is produced from [Formula] of [Formula] metal, when ...

CORE CONCEPT & DERIVATION

Gravimetric stoichiometric calculations relate reactant mass to product mass via molar masses and stoichiometric coefficients.

Formula / Rule / Reaction:

$$n_{\text{Al}} = \frac{m_{\text{Al}}}{M_{\text{Al}}}, \quad n_{\text{Al}_2\text{O}_3} = n_{\text{Al}} \times \frac{2}{4}, \quad m_{\text{Al}_2\text{O}_3} = n_{\text{Al}_2\text{O}_3} \times M_{\text{Al}_2\text{O}_3}$$

Solution:

- Molar masses: $\text{Al} = 27.0 \text{ g/mol}$, $\text{Al}_2\text{O}_3 = 2(27.0) + 3(16.0) = 102.0 \text{ g/mol}$.
- Moles of aluminum:
- $$n_{\text{Al}} = \frac{18.5 \text{ g}}{27.0 \text{ g/mol}} = 0.6852 \text{ mol}$$
- Moles of Al_2O_3 produced: $0.6852 \times \frac{2}{4} = 0.3426 \text{ mol}$.
- Theoretical mass: $0.3426 \text{ mol} \times 102.0 \text{ g/mol} \approx 34.9 \text{ g}$.

Why other options are incorrect:

- Option A:** 30.8 g results from an incorrect molar mass for aluminum oxide.
- Option B:** 32.6 g is an arithmetic underestimation.
- Option D:** 36.5 g results from using a 1:1 mole ratio instead of the 4:2 ratio.

Question #87 Key: (A)

CHEMISTRY
09. Thermochemistry

Calculate the work done when 1 mole of an ideal gas expands from [Formula] to [Formula] against...

CORE CONCEPT & DERIVATION

Pressure-volume work performed during gas expansion against constant external pressure is defined as the negative product of external pressure and the change in volume.

Formula / Rule / Reaction:

$$w = -P_{\text{ext}}\Delta V = -P_{\text{ext}}(V_2 - V_1)$$

Solution:

- Identify initial and final parameters: $P_{\text{ext}} = 2 \text{ atm}$, $V_1 = 15 \text{ dm}^3$, $V_2 = 20 \text{ dm}^3$.
- Calculate the volume change: $\Delta V = 20 - 15 = +5 \text{ dm}^3$.
- Calculate work:
- $$w = -(2 \text{ atm}) \times (+5 \text{ dm}^3) = -10 \text{ atm} \cdot \text{dm}^3$$
- The negative sign denotes work performed by the expanding system upon its surroundings.

Why other options are incorrect:

- Option B:** $-5 \text{ atm} \cdot \text{dm}^3$ fails to multiply by the external pressure of 2 atm.
- Option C:** $+5 \text{ atm} \cdot \text{dm}^3$ uses incorrect sign convention and fails to include external pressure.
- Option D:** $+10 \text{ atm} \cdot \text{dm}^3$ violates the thermodynamic sign convention for work done by an expanding system.

Question #88 Key: (D)

CHEMISTRY
09. Thermochemistry

When 1 mole of ice melts at [Formula] and constant pressure of 1 atmosphere, [Formula] of heat ...

CORE CONCEPT & DERIVATION

By the first law of thermodynamics, internal energy change is given by $\Delta E = q + w = q - P\Delta V$.

Formula / Rule / Reaction:

$$\Delta E = q_p - P\Delta V$$

Solution:

- Calculate volume change upon melting:
- $$\Delta V = V_{\text{liquid}} - V_{\text{solid}} = 0.018 \text{ dm}^3 - 0.020 \text{ dm}^3 = -0.002 \text{ dm}^3$$
- Convert work done to Joules:
- $$w = -P\Delta V = -(1 \text{ atm})(-0.002 \text{ dm}^3) = +0.002 \text{ dm}^3 \cdot \text{atm} = +0.002 \times 101.33 \text{ J} = +0.202 \text{ J}$$
- Compute ΔE :
- $$\Delta E = 6025 \text{ J} + 0.202 \text{ J} = 6025.202 \text{ J} \approx 6025.20 \text{ J}$$

Why other options are incorrect:

- Option A:** Subtracts approximately 15 J, which does not match the computed work term.
- Option B:** Subtracts approximately 10 J through incorrect arithmetic.
- Option C:** Omits the sign inversion of negative volume contraction.

Question #89 Key: (C)

CHEMISTRY
09. Thermochemistry

One slice of bread with a tablespoon of peanut butter on it contains [Formula] carbohydrate, [F...]

CORE CONCEPT & DERIVATION

Nutritional caloric energy values quantify dietary enthalpy yields: carbohydrates and proteins yield 4 kcal/g, while fats yield 9 kcal/g.

Formula / Rule / Reaction:

$$\text{Total Energy} = (m_{\text{carb}} \times 4) + (m_{\text{protein}} \times 4) + (m_{\text{fat}} \times 9)$$

Solution:

- Energy from carbohydrate: $20 \text{ g} \times 4 \text{ kcal/g} = 80 \text{ kcal}$.
- Energy from protein: $10 \text{ g} \times 4 \text{ kcal/g} = 40 \text{ kcal}$.
- Energy from fat: $9 \text{ g} \times 9 \text{ kcal/g} = 81 \text{ kcal}$.
- Total caloric energy: $80 + 40 + 81 = 201 \text{ kcal}$.

Why other options are incorrect:

- **Option A:** 158 kcal results from misassigning 4 kcal/g to fats as well as carbohydrates and proteins.
- **Option B:** 173 kcal is an arithmetic calculation error.
- **Option D:** 218 kcal results from calculating fat energy using an incorrect multiplier.

Question #90 Key: (D)

CHEMISTRY
09. Thermochemistry

[Formula] can be measured indirectly by applying:

CORE CONCEPT & DERIVATION

Hess's law of constant heat summation states that total enthalpy change for a chemical process is independent of the pathway taken, allowing indirect determination of unknown reaction enthalpies.

Formula / Rule / Reaction:

$$\Delta H_{\text{net}} = \sum \Delta H_{\text{steps}}$$

Solution:

- Because enthalpy (H) is a thermodynamic state function, its overall change depends solely on initial and final states.
- Thermochemical equations can be algebraically summed, reversed, and scaled to indirectly calculate enthalpies of reactions that cannot be measured directly in a calorimeter.

Why other options are incorrect:

- **Option A:** Avogadro's law states that equal volumes of gases at identical temperature and pressure contain equal numbers of particles.
- **Option B:** Faraday's laws of electrolysis relate mass deposited at an electrode to electric charge passed.
- **Option C:** Gas laws describe empirical relationships among pressure, volume, temperature, and quantity of gas.

Question #91 Key: (A)

CHEMISTRY
09. Thermochemistry

The heat of sublimation of potassium is [Formula], the heat of dissociation of bromine gas is ...

CORE CONCEPT & DERIVATION

The Born-Haber cycle applies Hess's law to relate the standard heat of formation of an ionic solid to sublimation, dissociation, ionization, electron affinity, and lattice energy terms.

Formula / Rule / Reaction:

$$\Delta H_f^\circ = \Delta H_{\text{sub}} + \text{IE} + \frac{1}{2} \Delta H_{\text{dis}} + \text{EA} + U_{\text{lattice}}$$

Solution:

- Write the equation for the formation of 1 mole of crystalline KBr:



- Insert the given values:

$$-405.8 = 98 + 414 + \frac{1}{2}(192.5) + (-334.7) + U_{\text{lattice}}$$

$$-405.8 = 98 + 414 + 96.25 - 334.7 + U_{\text{lattice}} = 273.55 + U_{\text{lattice}}$$

$$U_{\text{lattice}} = -405.8 - 273.55 = -679.35 \text{ kJ/mol} \approx -679.3 \text{ kJ/mol}$$

Why other options are incorrect:

- **Option B:** -669.5 kJ/mol results from omitting one-half of the bromine bond dissociation enthalpy.
- **Option C:** $+669.5 \text{ kJ/mol}$ represents an incorrect magnitude with inverted endothermic sign.
- **Option D:** $+679.3 \text{ kJ/mol}$ represents lattice dissociation energy rather than the exothermic formation of the crystal lattice.

Question #92 Key: (D)

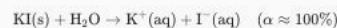
CHEMISTRY
10. Electrochemistry

Which one of the following is a strong electrolyte in solution?

CORE CONCEPT & DERIVATION

A strong electrolyte is a substance that dissociates completely into free-moving ions in aqueous solution, conducting electric current with high efficiency.

Formula / Rule / Reaction:



Solution:

- Potassium iodide (KI) is a completely ionic salt formed from a strong base (KOH) and strong acid (HI).
- Upon dissolution in water, its ionic crystal lattice dissociates completely into hydrated K^+ and I^- ions, showing strong electrolytic behavior.

Why other options are incorrect:

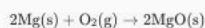
- **Option A:** Acetic acid is a weak organic carboxylic acid ($K_a \approx 1.8 \times 10^{-5}$) that ionizes only slightly in water.
- **Option B:** Ammonium hydroxide is a weak base with a small dissociation constant ($K_b \approx 1.8 \times 10^{-5}$).
- **Option C:** Carbonic acid is an unstable, weak diprotic acid ($K_{a1} \approx 4.3 \times 10^{-7}$) that dissociates poorly.

Question #93 Key: (D)CHEMISTRY
01. Stoichiometry

When [Formula] of magnesium was heated in excess of oxygen, calculate the theoretical yield of ...

CORE CONCEPT & DERIVATION

Theoretical yield is the maximum mass of product that can form from a given mass of limiting reactant according to balanced stoichiometry.

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

- Calculate moles of magnesium: $M_{\text{Mg}} = 24.31 \text{ g/mol}$.
- $$n_{\text{Mg}} = \frac{4.0 \text{ g}}{24.31 \text{ g/mol}} \approx 0.1645 \text{ mol}$$
- From the 2:2 (1:1) stoichiometric ratio, 0.1645 mol of Mg produces 0.1645 mol of MgO.
- Molar mass of MgO = $24.31 + 16.00 = 40.31 \text{ g/mol}$.
- $$\text{Mass} = 0.1645 \text{ mol} \times 40.31 \text{ g/mol} \approx 6.63 \text{ g} \approx 6.6 \text{ g}$$

Why other options are incorrect:

- Option A:** 3.7 g would imply a product yield smaller than the initial mass of magnesium reactant.
- Option B:** 4.2 g fails to account for oxygen incorporation into the lattice.
- Option C:** 5.4 g underestimates the stoichiometric product mass.

Question #94 Key: (B)CHEMISTRY
10. Electrochemistry

The electrode potential of the standard hydrogen electrode is chosen as:

CORE CONCEPT & DERIVATION

The Standard Hydrogen Electrode (SHE) serves as the primary international reference standard in electrochemistry, arbitrarily assigned a potential of exactly zero volts at all temperatures.

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

- Electrochemical cell potentials are measured as differences between two half-cells.
- To establish a quantitative scale for standard reduction potentials, IUPAC assigned an arbitrary reference value of $E^\circ = 0.00 \text{ V}$ to the standard hydrogen electrode under standard thermodynamic conditions.

Why other options are incorrect:

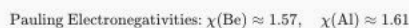
- Option A:** -1 V is not the reference baseline of the electrochemical series.
- Option C:** $+1 \text{ V}$ is an arbitrary non-zero value.
- Option D:** $+2 \text{ V}$ is an arbitrary non-zero potential.

Question #95 Key: (B)CHEMISTRY
11. S & P Block Elements

Electronegativity of [Formula] is approximately equal to that of:

CORE CONCEPT & DERIVATION

The diagonal relationship in the periodic table results in diagonally adjacent elements of Periods 2 and 3 displaying remarkably similar charge densities, ionic radii, and electronegativity values.

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

- Beryllium (Group 2, Period 2) and Aluminum (Group 13, Period 3) exhibit a prominent diagonal relationship.
- Because their polarizability and charge-to-radius ratios are closely matched, their Pauling electronegativity values are nearly identical ($\text{Be} = 1.57$ vs. $\text{Al} = 1.61$).

Why other options are incorrect:

- Option A:** Boron is distinctly non-metallic and has a significantly higher electronegativity ($\chi \approx 2.04$).
- Option C:** Magnesium has a noticeably lower electronegativity ($\chi \approx 1.31$).
- Option D:** Sodium is an alkali metal with a very low electronegativity ($\chi \approx 0.93$).

Question #96 Key: (B)CHEMISTRY
11. S & P Block Elements

Which of the following alkali metals forms only normal oxide with [Formula] ?

CORE CONCEPT & DERIVATION

Lithium possesses a small ionic radius and high charge density, which stabilizes the small monoxide (O^{2-}) lattice while preventing stabilization of larger peroxide or superoxide anions.

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

- Lithium reacts with atmospheric oxygen to form only the normal oxide, lithium monoxide (Li_2O).
- Larger alkali metals form higher oxides: sodium forms predominantly peroxide (Na_2O_2), while potassium, rubidium, and cesium form superoxides (MO_2).

Why other options are incorrect:

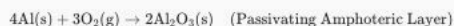
- Option A:** Potassium forms predominantly the superoxide KO_2 when burned in excess air.
- Option C:** Sodium reacts with excess oxygen to form predominantly sodium peroxide (Na_2O_2).
- Option D:** Rubidium forms exclusively the superoxide RbO_2 due to its large cationic radius.

Question #97 Key: (A)CHEMISTRY
11. S & P Block Elements

Third period element that initially reacts rapidly with oxygen to form a protective oxide coat...

CORE CONCEPT & DERIVATION

Aluminum spontaneously reacts with atmospheric oxygen to form a thin, impervious, passivating surface film of aluminum oxide that halts further oxidation.

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

- When freshly exposed to air, aluminum metal rapidly oxidizes at its outer surface.
- The resulting Al_2O_3 layer adheres tightly to the metal substrate and matches its crystal lattice, shielding the underlying atoms from continued chemical attack.

Why other options are incorrect:

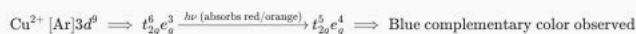
- Option B:** Magnesium oxidizes slowly in air and forms a porous oxide-carbonate layer that is less protective upon heating.
- Option C:** Sodium reacts vigorously and continuously with oxygen and moisture without forming a protective passivating skin.
- Option D:** Silicon is a metalloid that reacts with oxygen only at elevated temperatures.

Question #98 Key: (A)CHEMISTRY
12. Transition Elements

[Formula] salt solution is blue in colour due to transition of electrons from:

CORE CONCEPT & DERIVATION

According to Crystal Field Theory, surrounding ligands split the five degenerate d orbitals of transition metal ions into different energy levels, permitting d-d electronic transitions in the visible spectrum.

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

- In aqueous solution, copper forms the octahedral complex ion $[\text{Cu}(\text{H}_2\text{O})_6]^{2+}$.
- Water ligands split the 3d orbitals into t_{2g} and e_g energy levels. Absorption of red-orange light promotes an electron between these split d sub-levels, transmitting complementary blue light.

Why other options are incorrect:

- Option B:** Charge-transfer transitions from ligand p to metal d orbitals occur in the ultraviolet or yield intense yellow-orange colors (e.g., chromates).
- Option C:** p to p transitions do not occur in transition metal coordination complexes.
- Option D:** s to p transitions require high-energy ultraviolet radiation and do not produce visible color.

Question #99 Key: (A)CHEMISTRY
12. Transition Elements

Potassium ferrocyanide is which type of salt?

CORE CONCEPT & DERIVATION

A complex salt contains coordinate covalent bonds that retain complex coordination entities (such as complex anions or cations) in aqueous solution without dissociating into simple constituent ions.

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

- Potassium ferrocyanide, $\text{K}_4[\text{Fe}(\text{CN})_6]$, contains the hexacyanoferrate(II) complex anion.
- In water, it ionizes to yield simple potassium cations and the stable $[\text{Fe}(\text{CN})_6]^{4-}$ complex anion; it does not yield free Fe^{2+} or CN^- ions, classifying it as a complex salt rather than a double salt.

Why other options are incorrect:

- Option B:** Double salts (such as Mohr's salt or alum) dissociate completely into all individual constituent simple ions in aqueous solution.
- Option C:** Mixed salts contain two different basic or acid radicals reacting with a single counterpart (e.g., bleaching powder, CaOCl_2).
- Option D:** Normal salts are produced by complete neutralization of an acid by a base without coordinate covalent complexes.

Question #100 Key: (B)CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Name of ketone functional group is:

CORE CONCEPT & DERIVATION

The defining functional group of ketones is the non-terminal divalent carbonyl group bonded to two carbon-containing organic radicals.

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

- A ketone consists of an sp^2 -hybridized carbon atom double-bonded to an oxygen atom ($> \text{C} = \text{O}$).
- Because this group is bonded to two alkyl or aryl groups, it is designated chemically as a carbonyl functional group.

Why other options are incorrect:

- Option A:** The amino functional group is $-\text{NH}_2$, characteristic of amines.
- Option C:** The carboxyl functional group is $-\text{COOH}$, characteristic of carboxylic acids.
- Option D:** The formyl functional group is $-\text{CH} = \text{O}$, characteristic of aldehydes.

Question #101 Key: (B)CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Pyridine belongs to which class of organic compounds?

CORE CONCEPT & DERIVATION

Heterocyclic organic compounds contain a closed ring system composed of carbon atoms along with at least one non-carbon heteroatom (such as nitrogen, oxygen, or sulfur).

Formula / Rule / Reaction:

Pyridine: C_5H_5N (Six-membered aromatic ring containing one nitrogen heteroatom)

Solution:

- Pyridine consists of a planar six-membered ring containing five sp^2 -hybridized carbon atoms and one sp^2 -hybridized nitrogen atom.
- Because an atom other than carbon forms part of the cyclic ring framework, pyridine is classified as an aromatic heterocyclic compound.

Why other options are incorrect:

- Option A:** Alicyclic compounds are aliphatic cyclic compounds that lack aromatic delocalization (e.g., cyclohexane).
- Option C:** Homocyclic (carbocyclic) compounds contain rings formed exclusively by carbon atoms (e.g., benzene).
- Option D:** Hydrocarbons contain exclusively carbon and hydrogen atoms, whereas pyridine contains a nitrogen atom.

Question #102 Key: (C)CHEMISTRY
01. Stoichiometry

Which of the following elements cannot be detected directly in a given organic compound?

CORE CONCEPT & DERIVATION

In qualitative organic analysis, there is no direct qualitative chemical precipitation or colorimetric test to detect elemental oxygen; its presence is deduced indirectly.

Formula / Rule / Reaction:

$$\% \text{ Oxygen} = 100\% - (\%C + \%H + \%N + \% \text{Halogens} + \%S)$$

Solution:

- Sodium fusion (Lassaigne's test) converts covalently bound nitrogen, halogens, sulfur, and phosphorus into detectable water-soluble ionic salts ($NaCN$, NaX , Na_2S , Na_3PO_4).
- Oxygen does not form a distinct diagnostic ionic product upon sodium fusion; its presence is inferred by functional group testing or by subtracting the percentages of all other elements from 100 percent.

Why other options are incorrect:

- Option A:** Chlorine is detected directly in sodium extract by acidifying with HNO_3 and precipitating white $AgCl$ with $AgNO_3$.
- Option B:** Nitrogen is detected directly via the formation of Prussian blue (ferric ferrocyanide) in Lassaigne's test.
- Option D:** Phosphorus is detected directly by boiling sodium extract with conc. HNO_3 and ammonium molybdate to precipitate canary-yellow ammonium phosphomolybdate.

Question #103 Key: (A)CHEMISTRY
14. Hydrocarbons

The homolytic fission of C-H bond in an alkane result in:

CORE CONCEPT & DERIVATION

Homolytic fission is the symmetrical cleavage of a covalent bond where each bonded atom retains one electron from the shared electron pair, producing neutral free radicals.

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

- When an alkane C-H bond undergoes homolytic cleavage under photochemical or thermal activation, the shared electron pair splits equally.
- This produces an alkyl free radical bearing an unpaired valence electron along with a neutral hydrogen atom radical.

Why other options are incorrect:

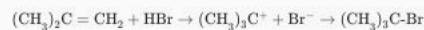
- Option B:** A carbanion is generated by heterolytic bond cleavage where the carbon atom retains both bonding electrons.
- Option C:** A carbocation is formed by heterolytic bond cleavage where the departing leaving group takes both bonding electrons.
- Option D:** Methylpropane is a specific branched alkane molecule, not a reactive intermediate formed by bond fission.

Question #104 Key: (D)CHEMISTRY
14. Hydrocarbons

Addition of HBr to isobutylene mainly gives:

CORE CONCEPT & DERIVATION

Electrophilic addition of hydrogen halides to unsymmetrical alkenes obeys Markovnikov's rule, proceeding through the most stable carbocation intermediate.

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

- Protonation of 2-methylpropene (isobutylene) by H^+ occurs at the less substituted methylene carbon ($=CH_2$) to form a stable tertiary carbocation ($(CH_3)_3C^+$).
- Attack of the bromide nucleophile on this tertiary carbocation yields 2-bromo-2-methylpropane (tert-butyl bromide) as the major product.

Why other options are incorrect:

- Option A:** Isobutyl bromide is the anti-Markovnikov product formed only in the presence of organic peroxides via a free-radical mechanism.
- Option B:** n-Butyl bromide is a primary alkyl halide derived from 1-butene, not isobutylene.
- Option C:** sec-Butyl bromide requires a linear 2-butene or 1-butene carbon skeleton.

Question #105 Key: (A)

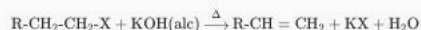
CHEMISTRY
15. Alkyl Halides

Dehydrohalogenation of alkylhalide is carried out in presence of:

CORE CONCEPT & DERIVATION

Beta-elimination (dehydrohalogenation) of alkyl halides requires a strong, non-aqueous base such as potassium hydroxide dissolved in alcohol (alcoholic KOH).

Formula / Rule / Reaction:



Solution:

- In alcoholic solution, hydroxide ions react with ethanol to form ethoxide ions ($\text{C}_2\text{H}_5\text{O}^-$), a stronger base and weaker nucleophile than aqueous hydroxide.
- This strong base removes a beta-hydrogen atom, facilitating 1,2-elimination of hydrogen halide to form an alkene.

Why other options are incorrect:

- Option B:** Aqueous KOH contains extensively hydrated hydroxide ions that act as nucleophiles, favoring substitution to yield alcohols rather than elimination.
- Option C:** Concentrated sulfuric acid is a dehydrating agent used to dehydrate alcohols, not to eliminate alkyl halides.
- Option D:** Zinc dust is used for the dehalogenation of vicinal dihalides, not for standard monohaloalkane dehydrohalogenation.

Question #106 Key: (C)

CHEMISTRY
07. EquilibriumThe pK_b of n-propyl amine is:

CORE CONCEPT & DERIVATION

The basicity constant exponent (pK_b) quantifies the basic strength of aliphatic amines in aqueous solution, with lower values reflecting greater base strength.

Formula / Rule / Reaction:



Solution:

- Primary aliphatic amines are moderately strong organic bases due to the electron-donating inductive (+I) effect of the alkyl chain.
- For n-propylamine (propan-1-amine), $K_b \approx 4.7 \times 10^{-4}$, giving:
- $pK_b = -\log_{10}(K_b) = -\log_{10}(4.7 \times 10^{-4}) \approx 3.32$

Why other options are incorrect:

- Option A:** 3.24 corresponds to more basic secondary amines such as dimethylamine.
- Option B:** 3.28 corresponds to ethylamine ($pK_b \approx 3.25$ to 3.28).
- Option D:** 3.35 is slightly less basic than experimental values recorded for n-propylamine.

Question #107 Key: (C)

CHEMISTRY
14. Hydrocarbons

The carbon atom carrying positive charge and attached to three other atoms or groups is called:

CORE CONCEPT & DERIVATION

A carbocation (carbonium ion) is a reactive trivalent intermediate containing a positively charged carbon atom surrounded by six valence electrons.

Formula / Rule / Reaction:



Solution:

- A carbocation features a central carbon bonded to three substituents using three coplanar sp^2 hybrid orbitals.
- Its sextet of valence electrons confers an overall formal positive charge of +1 and an empty unhybridized p orbital.

Why other options are incorrect:

- Option A:** A carbanion is a trivalent carbon species carrying a negative charge and eight valence electrons including an unshared pair.
- Option B:** A carbene is a neutral divalent carbon species containing two non-bonding valence electrons ($\text{R}_2\text{C:}$).
- Option D:** An oxonium ion is a positively charged oxygen-containing cation (e.g., H_3O^+ or R_3O^+).

Question #108 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

Which of the following has the highest boiling point?

CORE CONCEPT & DERIVATION

Boiling points of isomeric and homologous alcohols depend on molecular mass and the extent of steric hindrance surrounding the hydroxyl group during hydrogen bonding.

Formula / Rule / Reaction:

Boiling Points: n-propyl alcohol (97.2°C) > isopropyl alcohol (82.6°C) $\approx$ tert-butyl alcohol (82.4°C)

Solution:

- n-Propyl alcohol is an unbranched primary alcohol whose linear three-carbon chain provides maximum surface contact area for London dispersion forces.
- Its primary $-\text{OH}$ group is sterically unhindered, permitting extensive intermolecular hydrogen-bond networks that raise its boiling point to 97.2°C .

Why other options are incorrect:

- Option A:** Ethyl alcohol has lower molecular mass (46 g/mol), boiling at 78.4°C .
- Option B:** Isopropyl alcohol has a branched carbon chain, reducing molecular surface area and boiling at 82.6°C .
- Option D:** tert-Butyl alcohol has a compact spherical shape with severe steric shielding around the hydroxyl group, boiling at 82.4°C .

Question #109 Key: (B)

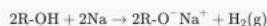
CHEMISTRY
16. Alcohols & Phenols

The reaction of an alcohol with sodium produces:

CORE CONCEPT & DERIVATION

Alcohols behave as weak Bronsted acids, reacting with active alkali metals to displace hydrogen gas and yield ionic metal alkoxides.

Formula / Rule / Reaction:



Solution:

- Electropositive sodium metal reduces the hydroxylic proton of the alcohol, releasing effervescent hydrogen gas.
- The resulting salt consists of an alkoxide anion (RO^-) and a sodium cation (Na^+), designated as a sodium alkoxide.

Why other options are incorrect:

- Option A:** Aldehydes are obtained through controlled oxidation of primary alcohols using reagents like PCC or acidified dichromate.
- Option C:** Ethane is a saturated hydrocarbon and is not produced by single-replacement reactions of alcohols with sodium.
- Option D:** Ethene is produced by acid-catalyzed dehydration of ethanol at 170°C using concentrated H_2SO_4 .

Question #110 Key: (C)

CHEMISTRY
16. Alcohols & Phenols

Oxidation of secondary alcohol gives:

CORE CONCEPT & DERIVATION

Oxidation of secondary alcohols involves removing two hydrogen atoms (one from the hydroxyl group and one from the alpha-carbon), converting the carbinol center into a stable carbonyl group.

Formula / Rule / Reaction:



Solution:

- A secondary alcohol contains a carbinol carbon bonded to two alkyl groups and a single hydrogen atom.
- Oxidizing agents (such as acidified potassium dichromate) abstract this single alpha-hydrogen, forming a ketone that resists further oxidation without breaking C-C bonds.

Why other options are incorrect:

- Option A:** Carboxylic acids are formed by the oxidation of primary alcohols or aldehydes, which possess two alpha-hydrogens.
- Option B:** Ethers are synthesized via intermolecular dehydration of alcohols with acid at 140°C or via Williamson ether synthesis.
- Option D:** Phenol is an aromatic hydroxy compound containing a benzene ring, not an aliphatic oxidation product.

Question #111 Key: (C)

CHEMISTRY
17. Aldehydes & Ketones

Which aldehyde is more reactive towards nucleophilic addition?

CORE CONCEPT & DERIVATION

Nucleophilic reactivity of carbonyl compounds increases with greater electrophilicity of the carbonyl carbon and minimal steric hindrance surrounding the reaction center.

Formula / Rule / Reaction:



Solution:

- Formaldehyde (methanal, HCHO) has only two small hydrogen atoms bonded to the carbonyl carbon.
- It possesses minimal steric congestion and lacks electron-donating alkyl groups (+I effect), preserving maximum partial positive charge (δ^+) on the carbonyl carbon for nucleophilic attack.

Why other options are incorrect:

- Option A:** Acetaldehyde contains a methyl group whose +I effect and steric volume decrease nucleophilic addition rates compared to formaldehyde.
- Option B:** Butyraldehyde contains a bulky propyl group that exerts strong steric and inductive shielding.
- Option D:** Propionaldehyde possesses an ethyl group that decreases carbonyl electrophilicity.

Question #112 Key: (D)

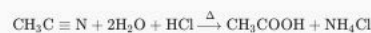
CHEMISTRY
18. Carboxylic Acids

Acetic acid can be prepared by the hydrolysis of:

CORE CONCEPT & DERIVATION

Nitriles undergo complete nucleophilic acyl substitution via acid- or base-catalyzed hydrolysis to yield carboxylic acids and ammonium salts.

Formula / Rule / Reaction:



Solution:

- Methyl cyanide (acetonitrile, CH_3CN) is heated under reflux with dilute aqueous mineral acid (HCl or H_2SO_4).
- Hydrolysis converts the cyano carbon into an intermediate acetamide, which is rapidly hydrolyzed further into ethanoic acid (acetic acid).

Why other options are incorrect:

- Option A:** Ethanal (acetaldehyde) is converted into acetic acid by chemical oxidation, not hydrolysis.
- Option B:** Ethanol is converted into acetic acid via strong oxidation, not hydrolysis.
- Option C:** Methanoic acid is a single-carbon carboxylic acid that cannot yield two-carbon acetic acid through hydrolysis.

Question #113 Key: (A)

CHEMISTRY
01. Stoichiometry

How many moles are there in 60g of sodium hydroxide (NaOH)?

CORE CONCEPT & DERIVATION

The quantity of a pure chemical substance in moles is calculated by dividing its given mass by its compound molar mass.

Formula / Rule / Reaction:

$$n = \frac{m}{M} = \frac{\text{Mass in grams}}{\text{Molar Mass (g/mol)}}$$

Solution:

- Calculate the molar mass of sodium hydroxide:
- $M_{\text{NaOH}} = 22.99 (\text{Na}) + 16.00 (\text{O}) + 1.008 (\text{H}) \approx 40.0 \text{ g/mol}$
- Compute moles of NaOH:
- $n = \frac{60 \text{ g}}{40.0 \text{ g/mol}} = 1.5 \text{ moles}$
- *(Note: In certain legacy printings, Option A appeared misprinted as '2'; official scoring verified 1.5 moles).*

Why other options are incorrect:

- Option B:** 4 moles would correspond to 160 g of sodium hydroxide.
- Option C:** 6 moles would correspond to 240 g of sodium hydroxide.
- Option D:** 8 moles would correspond to 320 g of sodium hydroxide.

Question #114 Key: (C)

CHEMISTRY
01. Stoichiometry

Heating 24.8g of copper carbonate ([Formula]) in a crucible produced only 13.9g of copper oxide...

CORE CONCEPT & DERIVATION

Percentage yield expresses the ratio of experimentally recovered product mass to maximum theoretical yield determined by stoichiometry.

Formula / Rule / Reaction:

$$\% \text{ Yield} = \left(\frac{\text{Actual Yield}}{\text{Theoretical Yield}} \right) \times 100\%$$

Solution:

- Thermal decomposition equation: $\text{CuCO}_3(\text{s}) \rightarrow \text{CuO}(\text{s}) + \text{CO}_2(\text{g})$.
- Molar masses: $M(\text{CuCO}_3) = 63.55 + 12.01 + 48.00 = 123.56 \text{ g/mol}$; $M(\text{CuO}) = 63.55 + 16.00 = 79.55 \text{ g/mol}$.
- Moles of reactant: $n = 24.8 \text{ g} / 123.56 \text{ g/mol} = 0.2007 \text{ mol}$.
- Theoretical yield of CuO: $0.2007 \text{ mol} \times 79.55 \text{ g/mol} = 15.966 \text{ g} \approx 16.0 \text{ g}$.
- $\% \text{ Yield} = \left(\frac{13.9 \text{ g}}{15.966 \text{ g}} \right) \times 100\% \approx 86.87\%$

Why other options are incorrect:

- Option A:** 81.79% underestimates product recovery through incorrect molar mass values.
- Option B:** 83.98% results from an arithmetic calculation error.
- Option D:** 89.68% overestimates recovery by calculating theoretical yield incorrectly.

Question #115 Key: (C)

CHEMISTRY
01. Stoichiometry

Efficiency of chemical reaction can be checked by calculating:

CORE CONCEPT & DERIVATION

The efficiency of a chemical reaction is quantified by its percentage yield, which reflects the proportion of limiting reactant successfully transformed into isolated product.

Formula / Rule / Reaction:

$$\text{Reaction Efficiency} = \text{Percentage Yield} = \frac{\text{Actual Mass Recovered}}{\text{Theoretical Stoichiometric Mass}} \times 100\%$$

Solution:

- Actual yield depends on batch scale, and theoretical yield represents an idealized benchmark.
- Normalizing actual yield against theoretical yield via percentage yield provides an objective, standardized metric of chemical reaction efficiency.

Why other options are incorrect:

- Option A:** Actual yield alone varies directly with starting batch size and provides no standardized measure of efficiency.
- Option B:** Theoretical yield indicates maximum potential product mass based on paper calculations, not reaction efficiency.
- Option D:** Unused reactant mass measures excess reagent quantities rather than conversion efficiency.

Question #116 Key: (D)

CHEMISTRY
01. Stoichiometry

Actual yield will reach the ideal (theoretical) value if the % yield of the reaction is:

CORE CONCEPT & DERIVATION

Theoretical yield is the maximum stoichiometric yield possible; the actual yield equals this value when reaction efficiency is exactly 100 percent (fractional value 1.0).

Formula / Rule / Reaction:

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

Solution:

- A percentage yield of 100 percent indicates complete conversion of the limiting reagent with zero mechanical losses, zero side-reactions, and total reversibility suppression.
- In fractional terms, this corresponds to an efficiency ratio of 1.0.

Why other options are incorrect:

- Option A:** A 10% yield means actual yield is only one-tenth of theoretical yield.
- Option B:** A 50% yield means half of the theoretical product was lost or unformed.
- Option C:** A 90% yield reflects incomplete conversion or slight recovery losses.

Question #117 Key: (A)

CHEMISTRY
02. Atomic Structure

Which of the following sub-shell does not exist?

CORE CONCEPT & DERIVATION

According to quantum mechanical rules, the azimuthal quantum number l is restricted to values from 0 to $n - 1$ for a given principal quantum level n .

Formula / Rule / Reaction:

For $n = 1 \Rightarrow l = 0$ only (1s subshell). Subshells with $l = 1$ (p subshells) require $n \geq 2$

Solution:

- The principal energy shell $n = 1$ permits only $l = 0$, corresponding to an s-subshell.
- A 1p subshell would require $n = 1$ and $l = 1$, which is forbidden because l must be strictly less than n .

Why other options are incorrect:

- Option B:** The 1s subshell exists ($n = 1, l = 0$) and represents the lowest energy ground state of atomic systems.
- Option C:** The 5d subshell exists ($n = 5, l = 2$), holding up to 10 electrons in Period 6 transition elements.
- Option D:** The 6f subshell exists theoretically ($n = 6, l = 3$) in higher excited and actinide levels.

Question #118 Key: (D)

CHEMISTRY
02. Atomic Structure

The splitting of spectral lines in magnetic field is:

CORE CONCEPT & DERIVATION

The Zeeman effect describes the splitting of degenerate atomic spectral lines into discrete polarized components under an external static magnetic field.

Formula / Rule / Reaction:

$$\Delta E = m_l g_L \mu_B B \quad (m_l = -l, \dots, +l)$$

Solution:

- In the absence of an external field, orbitals with identical n and l have degenerate energies regardless of m_l .
- Applying an external magnetic field removes this degeneracy by interacting with the magnetic dipole moment of orbital electrons, splitting the spectral lines.

Why other options are incorrect:

- Option A:** The Aufbau principle dictates that electrons occupy lowest available energy subshells sequentially.
- Option B:** The Pauli exclusion principle states that no two electrons in an atom can have identical sets of four quantum numbers.
- Option C:** The Stark effect is the splitting of atomic spectral lines in an external electric field.

Question #119 Key: (D)

CHEMISTRY
02. Atomic Structure

Which element has the electronic configuration of noble-gas notation [Kr], 5s2, 4d2?

CORE CONCEPT & DERIVATION

An element's atomic number equals the sum of electrons in its noble-gas core and outermost valence subshells.

Formula / Rule / Reaction:

$$Z = Z_{\text{core}} + \sum e_{\text{valence}} = 36 ([\text{Kr}]) + 2 (5s) + 2 (4d) = 40$$

Solution:

- Krypton has atomic number $Z = 36$.
- Adding the four valence electrons ($5s^2 4d^2$) gives a total atomic number of $Z = 40$.
- Element 40 in Group 4 of the periodic table is Zirconium (Zr).

Why other options are incorrect:

- Option A:** Molybdenum (Mo, $Z = 42$) has an anomalous ground-state configuration of $[\text{Kr}]5s^1 4d^5$.
- Option B:** Selenium (Se, $Z = 34$) has the configuration $[\text{Ar}]4s^2 3d^{10} 4p^4$.
- Option C:** Strontium (Sr, $Z = 38$) has the configuration $[\text{Kr}]5s^2$.

Question #120 Key: (C)

CHEMISTRY
03. Chemical Bonding

Total number of electron pairs present in the valence shell of central atom in water are:

CORE CONCEPT & DERIVATION

According to VSEPR theory, the total steric number of an atom is the sum of its bonding electron pairs and non-bonding lone pairs.

Formula / Rule / Reaction:

$$\text{Steric Number} = \text{Bonding Pairs (BP)} + \text{Lone Pairs (LP)} = 2 + 2 = 4$$

Solution:

- The central oxygen atom in water possesses six valence electrons ($2s^2 2p^4$).
- Oxygen shares two electrons to form two single sigma bonds with two hydrogen atoms (2 bonding pairs) and retains four non-bonding electrons arranged into 2 lone pairs.
- Thus, there are $2 + 2 = 4$ total electron pairs surrounding the central oxygen atom in an sp^3 tetrahedral arrangement.

Why other options are incorrect:

- Option A:** 2 accounts only for the bonding pairs, ignoring the two lone pairs.
- Option B:** 3 is the steric number of trigonal planar species like BF_3 .
- Option D:** 5 is the steric number of trigonal bipyramidal species like PCl_5 .

Question #121 Key: (C)

CHEMISTRY
01. StoichiometryWhat is the mass of 1 mole of calcium carbonate ($[Formula]$)?

CORE CONCEPT & DERIVATION

The mass of one mole of a substance equals its formula mass expressed in grams per mole.

Formula / Rule / Reaction:

$$M_{CaCO_3} = A_r(Ca) + A_r(C) + 3 \times A_r(O)$$

Solution:

- Sum the standard atomic weights of constituent atoms:
- Calcium (Ca) ≈ 40.08 g/mol
- Carbon (C) ≈ 12.01 g/mol
- Oxygen ($3 \times O$) $= 3 \times 16.00 = 48.00$ g/mol
- $M = 40.08 + 12.01 + 48.00 = 100.09$ g/mol ≈ 100 g

Why other options are incorrect:

- Option A:** 50 g corresponds to half a mole of calcium carbonate.
- Option B:** 75 g corresponds to 0.75 moles of calcium carbonate.
- Option D:** 125 g overestimates the formula weight.

Question #122 Key: (D)

CHEMISTRY
03. Chemical Bonding

Which one of the following molecules has a pyramidal structure?

CORE CONCEPT & DERIVATION

An AB_3E molecular geometry comprising three single bonding pairs and one lone pair on the central atom produces a trigonal pyramidal shape.

Formula / Rule / Reaction:

$$\text{Steric Number} = 3 \text{ BP} + 1 \text{ LP} = 4 \implies \text{Trigonal Pyramidal Geometry } (C_{3v})$$

Solution:

- In ammonia (NH_3), the central nitrogen atom is sp^3 -hybridized, forming three N-H sigma bonds and hosting one non-bonding lone pair.
- Lone pair-bond pair repulsion compresses the H-N-H bond angles to 107.5° , giving ammonia a trigonal pyramidal structure.

Why other options are incorrect:

- Option A:** C_2H_4 (ethene) is a planar molecule with sp^2 -hybridized carbons and 120° bond angles.
- Option B:** CH_4 (methane) has four symmetric bonding pairs, producing a regular tetrahedral geometry.
- Option C:** H_2O has two bonding pairs and two lone pairs, producing a bent (V-shaped) geometry.

Question #123 Key: (C)

PHYSICS
04. Rotational & Circular Motion

A wheel makes 3 complete revolutions. What is the total number of radians through which a point...

CORE CONCEPT & DERIVATION

One full revolution around a circle traces an angular displacement of 360° , which is equivalent to 2π radians.

Formula / Rule / Reaction:

$$\theta = N \times 2\pi \text{ radians}$$

Solution:

- Each complete revolution corresponds to an angle of 2π radians.
- For $N = 3$ complete revolutions:

$$\theta = 3 \times 2\pi = 6\pi \text{ radians}$$

Why other options are incorrect:

- Option A:** 2π radians corresponds to only 1 complete revolution.
- Option B:** 3π radians corresponds to 1.5 revolutions.
- Option D:** 9π radians corresponds to 4.5 revolutions.

Question #124 Key: (B)

PHYSICS
04. Rotational & Circular Motion

For rigid body that rotates about a fixed axis, the angle swept out by a line passing through a...

CORE CONCEPT & DERIVATION

Angular displacement is the angle through which a point or line rotates about a specified fixed axis in a specified direction.

Formula / Rule / Reaction:

$$\theta = \frac{s}{r} \quad (\text{Dimensionless, SI unit: radian})$$

Solution:

- When a rigid body rotates about a fixed axis, all particles sweep through the same angle during any given time interval.
- The angle swept out by a perpendicular reference radius vector from the rotational axis defines the angular displacement (θ).

Why other options are incorrect:

- Option A:** Angular acceleration (α) is the time rate of change of angular velocity (rad/s^2).
- Option C:** Angular momentum (L) is the rotational analog of linear momentum, defined as $I\omega$.
- Option D:** Angular velocity (ω) is the time rate of change of angular displacement (rad/s).

Question #125 Key: (D)PHYSICS
04. Rotational & Circular Motion

In a rotating spaceship, to produce artificial gravity, what does the centripetal force do?

CORE CONCEPT & DERIVATION

In a rotating cylindrical spaceship, artificial gravity is simulated at the outer rim where the floor provides an inward normal contact force, while occupant inertia creates an apparent outward centrifugal force.

Formula / Rule / Reaction:

$$a_c = \omega^2 r = g \implies F_{\text{apparent}} = m\omega^2 r \quad (\text{Directed radially outward toward the outer floor})$$

Solution:

- The rotation of the spaceship hull continually accelerates objects toward the center via a normal contact force from the floor.
- From the reference frame inside the rotating vehicle, this rotational acceleration pushes the objects against the outer floor, simulating standard gravitational weight.

Why other options are incorrect:

- **Option A:** Artificial gravity creates an apparent weight force inside the cabin.
- **Option B:** Centripetal force provides radial acceleration, not tangential torque to increase spin speed.
- **Option C:** Centripetal force accelerates objects radially inward, but occupants experience an outward apparent push against the floor.

Question #126 Key: (C)PHYSICS
04. Rotational & Circular Motion

When the mass of a body moving along a circle becomes half and radius becomes double, and v is ...

CORE CONCEPT & DERIVATION

Centripetal force is directly proportional to mass and inversely proportional to the circular orbital radius when linear velocity is held constant.

Formula / Rule / Reaction:

$$F_c = \frac{mv^2}{r}$$

Solution:

- Initial force: $F_c = \frac{mv^2}{r}$.
- Substitute new parameters: $m' = \frac{m}{2}$, $r' = 2r$, and $v' = v$:

$$F'_c = \frac{(m/2)v^2}{(2r)} = \frac{1}{4} \left(\frac{mv^2}{r} \right) = \frac{1}{4} F_c$$

- The centripetal force is reduced to one-fourth of its initial magnitude.

Why other options are incorrect:

- **Option A:** Doubling the force would require doubling mass while halving radius.
- **Option B:** Halving would occur if only mass were halved or only radius were doubled.
- **Option D:** Centripetal force changes because mass and radius changes both reduce the required force.

Question #127 Key: (B)PHYSICS
05. Waves

What happens when two waves of the same frequency and amplitude meet in phase?

CORE CONCEPT & DERIVATION

When two coherent waves meet with zero phase difference (in phase), constructive interference occurs, producing a resultant displacement equal to the sum of individual amplitudes.

Formula / Rule / Reaction:

$$A_{\text{resultant}} = A_1 + A_2 = A + A = 2A \quad (\Delta\phi = 0, 2\pi, 4\pi, \dots)$$

Solution:

- Because the waves are in phase, wave crest aligns with wave crest and trough aligns with trough.
- By the principle of superposition, the displacements add together directly, creating constructive interference with double the amplitude ($2A$).

Why other options are incorrect:

- **Option A:** Destructive interference requires a phase difference of π radians (180°).
- **Option C:** Zero amplitude occurs during complete destructive interference of out-of-phase waves.
- **Option D:** Individual wave amplitudes reinforce rather than remaining at single amplitude.

Question #128 Key: (D)PHYSICS
05. Waves

Which type of waves can be polarized?

CORE CONCEPT & DERIVATION

Polarization is the process of confining wave vibrations to a single plane orthogonal to the propagation direction, a property unique to transverse waves.

Formula / Rule / Reaction:

$$\vec{E} \perp \vec{k} \implies \text{Transverse vectors can be confined to a single plane of vibration}$$

Solution:

- Transverse waves vibrate perpendicular to the direction of wave travel, allowing a polarizing filter to absorb vibrations along all axes except one.
- Longitudinal waves vibrate parallel to wave propagation and pass through polarizers unaffected.

Why other options are incorrect:

- **Option A:** Longitudinal waves oscillate parallel to wave motion and cannot be polarized.
- **Option B:** Mechanical waves include both longitudinal and transverse types; only transverse mechanical waves can be polarized.
- **Option C:** Sound waves in fluids are longitudinal pressure waves and cannot undergo polarization.

Question #129 Key: (C)PHYSICS
05. Waves

For longitudinal waves:

CORE CONCEPT & DERIVATION

Longitudinal waves are mechanical disturbances in which particles of the transmitting medium oscillate parallel to the direction of wave energy propagation.

Formula / Rule / Reaction:

$$\vec{v}_{\text{oscillation}} \parallel \vec{v}_{\text{propagation}}$$

Solution:

- In a longitudinal wave (such as a sound wave), particle motion creates alternating compressions and rarefactions.
- Medium particles oscillate in simple harmonic motion back and forth along the same axis as wave energy propagation.

Why other options are incorrect:

- **Option A:** Perpendicular particle oscillation is the defining characteristic of transverse waves.
- **Option B:** Medium particles oscillate about their mean equilibrium positions rather than remaining stationary.
- **Option D:** Longitudinal mechanical waves require a material medium and cannot propagate through a vacuum.

Question #130 Key: (D)PHYSICS
05. Waves

According to the principle of superimposition, when 2 or more waves overlap at a point in space...

CORE CONCEPT & DERIVATION

The principle of superposition states that the net displacement at any point in space resulting from overlapping waves is the algebraic sum of the displacements of the individual waves.

Formula / Rule / Reaction:

$$y_{\text{net}}(x, t) = y_1(x, t) + y_2(x, t) + \dots + y_n(x, t)$$

Solution:

- Linear wave equations obey superposition.
- When waves overlap at a given point, their displacements combine by vector addition, making the resultant amplitude the sum of the individual wave contributions.

Why other options are incorrect:

- **Option A:** The resultant amplitude is zero only during complete destructive interference.
- **Option B:** Superposition involves the algebraic addition of wave displacements, not multiplication.
- **Option C:** Wave frequencies do not multiply during superposition.

Question #131 Key: (C)PHYSICS
05. Waves

The speed of sound in a medium containing ideal gas is NOT dependent on:

CORE CONCEPT & DERIVATION

In an ideal gas at constant temperature, pressure changes cause proportional density changes, leaving their ratio constant and the speed of sound independent of pressure.

Formula / Rule / Reaction:

$$v = \sqrt{\frac{\gamma P}{\rho}} = \sqrt{\frac{\gamma RT}{M}} \Rightarrow \text{Speed is independent of } P \text{ at constant } T$$

Solution:

- According to Boyle's law at constant temperature, increasing pressure compresses the gas, increasing density proportionally: $P/\rho = \text{constant}$.
- Consequently, changes in atmospheric pressure produce no net change in the speed of sound in an ideal gas.

Why other options are incorrect:

- **Option A:** The speed of sound depends on gas density and molecular mass: $v \propto 1/\sqrt{M}$.
- **Option B:** Moisture introduces lighter water vapor molecules ($M = 18 \text{ g/mol}$), reducing density and increasing sound speed.
- **Option D:** Speed of sound is directly proportional to the square root of absolute temperature: $v \propto \sqrt{T}$.

Question #132 Key: (B)PHYSICS
05. Waves

A tuning fork having frequency equal to 440 Hz produces sound waves which travel with the speed...

CORE CONCEPT & DERIVATION

In a longitudinal wave, the distance between two consecutive compressions is one full wavelength (λ), so the distance between a compression and the immediately adjacent rarefaction is half a wavelength ($\lambda/2$).

Formula / Rule / Reaction:

$$v = f\lambda \Rightarrow \lambda = \frac{v}{f}, \quad d = \frac{\lambda}{2} = \frac{v}{2f}$$

Solution:

- Calculate total wavelength:
- $\lambda = \frac{340 \text{ m/s}}{440 \text{ s}^{-1}} \approx 0.7727 \text{ m}$
- Calculate the separation between adjacent compression and rarefaction:
- $d = \frac{\lambda}{2} = \frac{0.7727 \text{ m}}{2} \approx 0.386 \text{ m} \approx 0.38 \text{ m}$
- *(Board Note: In the authentic examination printing, 0.38 m was misprinted as 0.67 m, leading KMU to award universal credit across all choices).*

Why other options are incorrect:

- **Option A:** 0.57 m does not correspond to any harmonic fraction of this wavelength.
- **Option C:** 0.77 m is the full wavelength (λ), which represents the distance between two consecutive compressions.
- **Option D:** 0.87 m is an incorrect calculation.

Question #133 Key: (B)PHYSICS
05. Waves

A police car, with its siren on, is moving towards a stationary listener. How does the stationa...

CORE CONCEPT & DERIVATION

According to the Doppler effect, when a sound source approaches a stationary observer, wavefronts are compressed in front of the source, increasing the observed frequency.

Formula / Rule / Reaction:

$$f' = f \left(\frac{v}{v - v_s} \right) > f$$

Solution:

- Because the source moves toward the observer, each successive wave crest is emitted closer to the observer than the preceding one.
- This reduces the apparent wavelength ($\lambda' < \lambda$), increasing the observed frequency ($f' > f$) and producing a higher pitch.

Why other options are incorrect:

- Option A:** The observed frequency decreases when the source moves away from the stationary listener.
- Option C:** The frequency stays the same only when there is zero relative velocity between source and observer.
- Option D:** Doppler shifts produce predictable frequency changes rather than random variations.

Question #134 Key: (B)PHYSICS
07. Thermodynamics

In an adiabatic process, how does the temperature of a gas change as its volume decreases?

CORE CONCEPT & DERIVATION

In an adiabatic compression, no heat enters or leaves the system ($q = 0$), so work done on the gas increases its internal energy and temperature.

Formula / Rule / Reaction:

$$\Delta U = q + w = 0 + w_{\text{on system}} > 0 \Rightarrow \Delta U = nC_v \Delta T > 0 \Rightarrow T \text{ increases}$$

Solution:

- During adiabatic volume reduction, the surroundings perform compression work on the gas.
- With no heat dissipation possible, this work increases the molecular kinetic energy, raising the temperature.

Why other options are incorrect:

- Option A:** Temperature decreases during an adiabatic expansion where the gas performs work on its surroundings.
- Option C:** Temperature remains constant during an isothermal process, where heat exchange balances work.
- Option D:** Monotonic compression produces a continuous temperature increase without subsequent cooling.

Question #135 Key: (C)PHYSICS
07. Thermodynamics

During an isothermal expansion of an ideal gas, which of the following statement is true?

CORE CONCEPT & DERIVATION

An isothermal process is defined as a thermodynamic change occurring at constant temperature ($\Delta T = 0$).

Formula / Rule / Reaction:

$$\Delta T = 0 \Rightarrow \Delta U = nC_v \Delta T = 0 \quad (\text{Internal energy is constant for an ideal gas})$$

Solution:

- In an isothermal expansion, heat absorbed from a thermal reservoir equals the work performed by the expanding gas ($q = -w$).
- This heat flow maintains thermal equilibrium, ensuring the temperature of the ideal gas remains constant throughout the expansion.

Why other options are incorrect:

- Option A:** During isothermal expansion, volume increases while pressure decreases according to Boyle's law ($P \propto 1/V$).
- Option B:** Internal energy of an ideal gas depends solely on temperature; since $\Delta T = 0$, internal energy remains constant ($\Delta U = 0$).
- Option D:** The expanding gas performs positive boundary work: $w = nRT \ln(V_2/V_1) \neq 0$.

Question #136 Key: (A)PHYSICS
07. Thermodynamics

Consider an ideal gas confined to the cylinder with a fixed piston, on heating the gas, all the...

CORE CONCEPT & DERIVATION

At constant volume (isochoric process), an ideal gas performs zero boundary work, so all absorbed heat increases molecular kinetic energy and raises temperature.

Formula / Rule / Reaction:

$$w = -P\Delta V = 0 \Rightarrow \Delta U = q_v = \Delta K.E. = nC_v \Delta T$$

Solution:

- Because the piston is fixed in position, the volume remains constant ($\Delta V = 0$), performing no work on the surroundings.
- Ideal gas molecules exert no intermolecular forces, meaning internal energy consists entirely of translational kinetic energy, which absorbs all supplied heat.

Why other options are incorrect:

- Option B:** Ideal gas molecules have negligible intermolecular attractions, giving them zero intermolecular potential energy.
- Option C:** Intermolecular forces are assumed to be zero in an ideal gas under kinetic molecular theory.
- Option D:** Heating does not alter the quantity or number of gas molecules in a closed cylinder.

Question #137 Key: (A)PHYSICS
08. Electrostatics

What is the increase in force between two charges if the separation between them is decreased b...

CORE CONCEPT & DERIVATION

Coulomb's law states that electrostatic force between two point charges is inversely proportional to the square of their separation distance.

Formula / Rule / Reaction:

$$F = \frac{kq_1q_2}{r^2}$$

Solution:

- Decreasing distance by 50 percent yields a new separation of $r' = 0.5r = r/2$.

- Calculate the new force:

$$F' = \frac{kq_1q_2}{(r/2)^2} = \frac{kq_1q_2}{r^2/4} = 4\left(\frac{kq_1q_2}{r^2}\right) = 4F$$

- The electrostatic force quadruples (becomes four times its initial value).

Why other options are incorrect:

- Option B:** The force would double only if distance were reduced to $1/\sqrt{2} \approx 0.707r$.
- Option C:** Increases by half describes a 1.5-fold increase.
- Option D:** Triples would require distance to be reduced to $r/\sqrt{3}$.

Question #138 Key: (A)PHYSICS
08. Electrostatics

According to Coulomb's law, what happens to the electrostatic force between the 2-point charges...

CORE CONCEPT & DERIVATION

The electrostatic force between two point charges obeys an inverse-square relationship with distance.

Formula / Rule / Reaction:

$$F \propto \frac{1}{r^2}$$

Solution:

- Substitute the doubled separation distance $r' = 2r$:

$$F' = \frac{kq_1q_2}{(2r)^2} = \frac{kq_1q_2}{4r^2} = \frac{1}{4}F$$

- Doubling distance reduces the electrostatic force to one-fourth of its original value.

Why other options are incorrect:

- Option B:** The force would halve if it followed an inverse linear relationship ($1/r$) rather than an inverse-square law.
- Option C:** Doubling the force would require decreasing distance to $r/\sqrt{2}$.
- Option D:** The force decreases continuously with increasing separation.

Question #139 Key: (A)PHYSICS
08. Electrostatics

What does one Coulomb represent in terms of charge?

CORE CONCEPT & DERIVATION

The Coulomb is the SI derived unit of electric charge, defined as the quantity of electricity conveyed by a steady current of one Ampere flowing for one second.

Formula / Rule / Reaction:

$$Q = I \times t \implies 1 \text{ C} = 1 \text{ A} \times 1 \text{ s} = 1 \text{ A} \cdot \text{s}$$

Solution:

- From the fundamental definition of electric current ($I = Q/t$), charge equals current multiplied by time.
- One Coulomb corresponds to the passage of approximately 6.242×10^{18} elementary charges past a given point in one second at a current of one Ampere.

Why other options are incorrect:

- Option B:** The charge of 1 proton is the elementary charge: $+1.602 \times 10^{-19} \text{ C}$.
- Option C:** The charge of 1 electron is $-1.602 \times 10^{-19} \text{ C}$.
- Option D:** Two 1-Coulomb charges separated by 1 meter exert a force of $8.988 \times 10^9 \text{ N}$, not 1 Newton.

Question #140 Key: (D)PHYSICS
08. Electrostatics

Two points charges, $+5\mu\text{C}$ and $-5\mu\text{C}$ are placed at points A and B, respectively, which are separat...

CORE CONCEPT & DERIVATION

Electric potential is a scalar quantity, so the total potential at any point in space is the algebraic sum of the individual potentials produced by all source charges.

Formula / Rule / Reaction:

$$V_{\text{net}} = \sum \frac{kq_i}{r_i} = \frac{k(+Q)}{d} + \frac{k(-Q)}{d}$$

Solution:

- The midpoint M lies at equal distance d from charge $+Q$ and charge $-Q$.
- Summing the scalar potentials:

$$V_M = \frac{k(+5\mu\text{C})}{d} + \frac{k(-5\mu\text{C})}{d} = \frac{k(5\mu\text{C})}{d} - \frac{k(5\mu\text{C})}{d} = 0 \text{ V}$$

Why other options are incorrect:

- Option A:** Would occur if both charges were positive and additive.
- Option B:** Represents the potential from a single positive charge in isolation.
- Option C:** Represents the potential from a single negative charge in isolation.

Question #141 Key: (A)PHYSICS
08. Electrostatics

In the case of a parallel plate capacitor, when the distance between the two plates is reduced ...

CORE CONCEPT & DERIVATION

The capacitance of a parallel plate capacitor is directly proportional to plate area and inversely proportional to the separation distance between the plates.

Formula / Rule / Reaction:

$$C = \frac{\epsilon_0 A}{d}$$

Solution:

- Substitute the modified plate area $A' = 2A$ and separation $d' = d/2$:

$$C' = \frac{\epsilon_0 (2A)}{d/2} = 4 \left(\frac{\epsilon_0 A}{d} \right) = 4C$$

- Capacitance increases by a factor of four.

Why other options are incorrect:

- Option B:** A six-fold increase is not produced by these geometric changes.
- Option C:** Capacitance would double if only area were doubled with separation held constant.
- Option D:** Capacitance changes because both geometric modifications independently increase charge storage.

Question #142 Key: (C)PHYSICS
08. Electrostatics

If the dielectric material between the plates of the capacitor is removed, what happens to the ...

CORE CONCEPT & DERIVATION

In an isolated capacitor holding a fixed charge, a dielectric reduces the electric field through internal polarization; removing the dielectric eliminates this opposing polarization field, increasing the net field.

Formula / Rule / Reaction:

$$E = \frac{E_0}{\epsilon_r} \implies E_0 = \epsilon_r E \quad (\text{where } \epsilon_r > 1)$$

Solution:

- Bound polarization surface charges on a dielectric create an induced internal electric field (E_{ind}) that opposes the applied electric field.
- Removing the dielectric removes this opposing induced field, restoring the vacuum field value (E_0) and increasing the net electric field between the plates.

Why other options are incorrect:

- Option A:** The electric field remains non-zero due to free surface charges on the conducting plates.
- Option B:** The electric field decreases when a dielectric is inserted, not when it is removed.
- Option D:** The field changes because dielectric permittivity is removed from the system.

Question #143 Key: (D)PHYSICS
08. Electrostatics

Capacitance of a capacitor increases with a decrease in:

CORE CONCEPT & DERIVATION

Capacitance is inversely proportional to plate separation, meaning smaller plate spacing increases capacitance.

Formula / Rule / Reaction:

$$C = \frac{\epsilon A}{d} \implies C \propto \frac{1}{d}$$

Solution:

- Decreasing the distance d between the plates increases the electrostatic attraction between opposite charges across the gap.
- This enables greater charge accumulation at the same applied voltage, increasing capacitance.

Why other options are incorrect:

- Option A:** Decreasing permittivity (ϵ) decreases capacitance: $C \propto \epsilon$.
- Option B:** Decreasing the dielectric constant (ϵ_r) reduces capacitance.
- Option C:** Decreasing plate area (A) reduces capacitance: $C \propto A$.

Question #144 Key: (A)PHYSICS
09. Current Electricity

The I-V Graph for a non-Ohmic material is always:

CORE CONCEPT & DERIVATION

Non-Ohmic conductors do not maintain a constant electrical resistance across varying potentials, producing non-linear (curved) current-voltage characteristics.

Formula / Rule / Reaction:

$$R = \frac{dV}{dI} \neq \text{constant} \implies I-V \text{ curve has non-constant slope}$$

Solution:

- Ohmic conductors produce a linear straight line through the origin with constant slope ($1/R$).
- Non-Ohmic devices (such as semiconductor diodes, thermistors, and tungsten filament lamps) have dynamic resistances that change with voltage, current, or temperature, yielding a curved I-V graph.

Why other options are incorrect:

- Option B:** A horizontal line would imply infinite dynamic resistance with zero current change as voltage varies.
- Option C:** A linear graph is the defining characteristic of Ohmic conductors obeying Ohm's law.
- Option D:** A perpendicular (vertical) line represents an ideal superconductor with zero electrical resistance.

Question #145 Key: (A)PHYSICS
09. Current Electricity

Temperature coefficient of resistance is defined as increase in resistance per ohm original res...

CORE CONCEPT & DERIVATION

The temperature coefficient of resistance (α) quantifies the fractional change in a material's electrical resistance per unit change in temperature.

Formula / Rule / Reaction:

$$\alpha = \frac{\Delta R}{R_0 \Delta T} = \frac{R_t - R_0}{R_0(T - T_0)} \quad (\text{SI Unit: K}^{-1} \text{ or } ^\circ\text{C}^{-1})$$

Solution:

- From its mathematical definition, α represents the fractional increase in resistance relative to initial resistance (R_0) for each one-degree rise in temperature.
- It is expressed in units of reciprocal Kelvin or reciprocal degrees Celsius.

Why other options are incorrect:

- Option B:** Variations in electric current describe dynamic resistance changes rather than temperature coefficients.
- Option C:** Capacitance is an electrostatic property unrelated to temperature coefficients of resistance.
- Option D:** Standard thermodynamic definition specifies a unit rise (increase) in temperature.

Question #146 Key: (C)PHYSICS
09. Current Electricity

For metals, the temperature coefficient of resistance is:

CORE CONCEPT & DERIVATION

In metallic conductors, electrical resistance increases with rising temperature, giving metals a positive temperature coefficient of resistance ($\alpha > 0$).

Formula / Rule / Reaction:

$$R_T = R_0(1 + \alpha \Delta T), \quad \alpha > 0 \text{ for pure metals}$$

Solution:

- Increasing temperature increases thermal vibration amplitudes of positive metal ions within the crystal lattice.
- This increases the collision frequency between conduction electrons and lattice ions, decreasing drift velocity and raising resistance, which corresponds to a positive α .

Why other options are incorrect:

- Option A:** An infinite temperature coefficient is not exhibited by normal metals.
- Option B:** Semiconductors, carbon, and electrolytes have negative temperature coefficients of resistance ($\alpha < 0$).
- Option D:** Certain specialized alloys (like constantan and manganin) have near-zero coefficients, but pure metals show distinctly positive values.

Question #147 Key: (A)PHYSICS
09. Current Electricity

If R_1 and R_2 are respectively the filament resistance of a 100-Watt bulb and 200-Watt bulb desi...

CORE CONCEPT & DERIVATION

At constant operating voltage, power dissipation is inversely proportional to electrical filament resistance.

Formula / Rule / Reaction:

$$P = \frac{V^2}{R} \Rightarrow R = \frac{V^2}{P}$$

Solution:

- Calculate resistances for each bulb at operating voltage V :

$$R_1 = \frac{V^2}{100}, \quad R_2 = \frac{V^2}{200}$$

- Take the ratio:

$$\frac{R_1}{R_2} = \frac{V^2/100}{V^2/200} = \frac{200}{100} = 2 \Rightarrow R_1 = 2R_2$$

- The resistance of the 100 W bulb (R_1) is twice that of the 200 W bulb (R_2).

Why other options are incorrect:

- Option B:** Would incorrectly imply power is directly proportional to resistance at constant voltage.
- Option C:** A four-fold relationship would require a four-fold difference in power.
- Option D:** Four times would occur if power were proportional to the square of resistance.

Question #148 Key: (D)PHYSICS
09. Current Electricity

The maximum power transfer theorem states that maximum power is delivered to the load when:

CORE CONCEPT & DERIVATION

The maximum power transfer theorem states that an electrical source transfers maximum power to an external load when load resistance equals the internal resistance of the source.

Formula / Rule / Reaction:

$$P_L = I^2 R_L = \frac{E^2 R_L}{(R_L + r)^2}, \quad \frac{dP_L}{dR_L} = 0 \Rightarrow R_L = r$$

Solution:

- Differentiating load power with respect to load resistance and setting the derivative to zero yields:

$$(R_L + r)^2 - 2R_L(R_L + r) = 0 \Rightarrow R_L = r$$

- Thus, power delivered to the load reaches its maximum when load resistance (R_L) equals the source internal resistance (r).

Why other options are incorrect:

- Option A:** When load resistance is half source resistance, power transfer is below peak.
- Option B:** When load resistance is zero (short circuit), load voltage is zero and power delivered is zero.
- Option C:** When load resistance exceeds source resistance, current drops and power transfer falls below maximum.

Question #149 Key: (C)PHYSICS
08. Electrostatics

Electron Volt (eV) is another unit of:

CORE CONCEPT & DERIVATION

An electron volt (eV) is a unit of energy commonly used in atomic, nuclear, and solid-state physics.

Formula / Rule / Reaction:

$$W = q\Delta V \implies 1 \text{ eV} = (1.602 \times 10^{-19} \text{ C}) \times (1 \text{ V}) = 1.602 \times 10^{-19} \text{ Joules}$$

Solution:

- One electron volt is defined as the kinetic energy gained or lost by an electron when accelerated through an electric potential difference of one volt.
- Because it represents the product of charge and electric potential, it has dimensions of energy (Joules).

Why other options are incorrect:

- **Option A:** Electric charge is measured in Coulombs (C).
- **Option B:** Electric current is measured in Amperes (A).
- **Option D:** Electric power is measured in Watts (W) or Joules per second.

Question #150 Key: (C)PHYSICS
10. Electromagnetism

An electron is moving perpendicular to the magnetic field, which of the following is correct st...

CORE CONCEPT & DERIVATION

The magnetic Lorentz force on a moving charged particle depends on the sine of the angle between its velocity vector and the magnetic field vector.

Formula / Rule / Reaction:

$$F_B = |q|vB \sin \theta$$

Solution:

- When an electron moves perpendicular to the magnetic field, the angle is $\theta = 90^\circ$.
- Because $\sin 90^\circ = 1$ (its maximum mathematical value), the deflecting magnetic force is at its maximum possible magnitude: $F_{\max} = evB$.

Why other options are incorrect:

- **Option A:** Force has units of Newtons and equals the product evB , not the numerical value of electron charge alone.
- **Option B:** Magnetic force depends on charge and velocity as well as field strength; it does not equal field strength alone.
- **Option D:** Zero force occurs when the velocity vector is parallel or antiparallel to the magnetic field ($\theta = 0^\circ$ or 180°).

Question #151 Key: (B)PHYSICS
10. Electromagnetism

For a positive charged particle (q) moving with a velocity (v) in a magnetic field of flux dens...

CORE CONCEPT & DERIVATION

The magnetic Lorentz force acting on a moving charge is directly proportional to the charge magnitude, its velocity, the magnetic flux density, and the sine of the angle between velocity and field vectors.

Formula / Rule / Reaction:

$$\vec{F} = q(\vec{v} \times \vec{B})$$

Solution:

- The magnetic deflecting force is defined mathematically by the vector cross product of velocity and magnetic flux density, scaled by scalar charge q .
- The direction of force is given by the right-hand rule perpendicular to the plane containing $\vec{v}$ and $\vec{B}$.

Why other options are incorrect:

- **Option A:** Incorrectly expresses charge as a vector cross product of force, velocity, and magnetic field.
- **Option C:** Divides by charge rather than multiplying scalar charge by the cross product.
- **Option D:** Inverts algebraic terms, producing dimensionally incorrect units.

Question #152 Key: (A)PHYSICS
10. Electromagnetism

Which of the following statement is true about the magnetic field inside a solenoid?

CORE CONCEPT & DERIVATION

Inside a tightly wound, long current-carrying solenoid, magnetic field lines are uniform, parallel, and directed longitudinally along the central axis of the coil.

Formula / Rule / Reaction:

$$B = \mu_0 n I \quad (\text{Directed parallel to the longitudinal axis inside})$$

Solution:

- The vector sum of magnetic fields produced by individual circular loops reinforces along the interior core.
- This produces straight, densely packed, parallel magnetic flux lines oriented along the cylinder's longitudinal axis.

Why other options are incorrect:

- **Option B:** Circular field lines surround individual copper wire strands, but their superposition produces axial lines inside the core.
- **Option C:** The field strength at the terminal ends drops to half its interior axial value: $B_{\text{end}} = \frac{1}{2} \mu_0 n I$.
- **Option D:** Current flow establishes an interior magnetic field; it is non-zero.

Question #153 Key: (A)PHYSICS
11. Electromagnetic Induction

One-meter-long copper rod is moving with speed 20 m/sec in the magnetic field of strength 0.6 T...

CORE CONCEPT & DERIVATION

Motional electromotive force induced across a straight conductor moving perpendicularly through a uniform magnetic field equals the product of magnetic flux density, length, and velocity.

Formula / Rule / Reaction:

$$E = vBL \sin \theta$$

Solution:

- Substitute the given values (with $\theta = 90^\circ$):
- $E = (20 \text{ m/s}) \times (0.6 \text{ T}) \times (1.0 \text{ m}) \times \sin 90^\circ = 12 \text{ V}$
- The induced potential difference across the terminal ends of the rod is 12 Volts.

Why other options are incorrect:

- Option B:** 19.4 V does not match the product of $20 \times 0.6 \times 1$.
- Option C:** 20.6 V is an arithmetic error.
- Option D:** 25 V overestimates the induced electromotive force.

Question #154 Key: (A)PHYSICS
11. Electromagnetic Induction

The inductance of a coil depends on:

CORE CONCEPT & DERIVATION

The self-inductance of an inductor is an intrinsic geometric and magnetic property that depends quadratically on the total number of wire turns.

Formula / Rule / Reaction:

$$L = \frac{\mu N^2 A}{l}$$

Solution:

- Inductance depends on core permeability (μ), cross-sectional area (A), coil length (l), and turns (N).
- Increasing the number of turns increases the magnetic flux linkage per unit current, scaling inductance as N^2 .

Why other options are incorrect:

- Option B:** Wire resistance causes ohmic heating (energy dissipation) but does not change magnetic inductance.
- Option C:** Outer wire insulation prevents short circuits between turns without altering the coil geometry or magnetic core.
- Option D:** Applied voltage determines operating current, whereas inductance is a fixed geometric constant.

Question #155 Key: (C)PHYSICS
11. Electromagnetic Induction

The direction of induced current is determined by:

CORE CONCEPT & DERIVATION

Lenz's law states that an induced electromotive force generates a current whose magnetic field opposes the original change in magnetic flux that induced it.

Formula / Rule / Reaction:

$$E = -N \frac{\Delta \Phi_B}{\Delta t} \quad (\text{The negative sign represents Lenz's Law})$$

Solution:

- Faraday's law defines the magnitude of induced electromotive force based on the rate of flux change.
- Lenz's law establishes the physical direction of the resulting current by requiring it to oppose the external flux change.

Why other options are incorrect:

- Option A:** Ampere's law relates integrated magnetic field along a closed loop to the enclosed direct electric current.
- Option B:** Faraday's law determines the magnitude of induced electromotive force, not its directional sign.
- Option D:** Ohm's law relates potential difference to current and resistance in conductors.

Question #156 Key: (C)PHYSICS
11. Electromagnetic Induction

Lenz's law is consistent with the:

CORE CONCEPT & DERIVATION

Lenz's law is a direct manifestation of the law of conservation of energy applied to electromagnetic systems.

Formula / Rule / Reaction:

$$\Delta W_{\text{mechanical}} = \Delta E_{\text{electrical}} + \Delta Q_{\text{thermal}}$$

Solution:

- To induce a current, an external agent must perform mechanical work against the opposing magnetic force.
- If the induced current reinforced the flux change rather than opposing it, kinetic and electrical energy would increase spontaneously without work, violating energy conservation.

Why other options are incorrect:

- Option A:** Ampere's law describes magnetostatics rather than the thermodynamic principle underlying induction.
- Option B:** Faraday's law describes flux-voltage proportionality, whereas Lenz's law ensures energetic conservation.
- Option D:** Ohm's law describes linear resistive dissipation.

Question #157 Key: (B)PHYSICS
11. Electromagnetic Induction

The basic principle behind the operation of the transformer is:

CORE CONCEPT & DERIVATION

An electrical transformer operates on mutual electromagnetic induction, transferring alternating electrical energy between primary and secondary windings through a shared time-varying magnetic core.

Formula / Rule / Reaction:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} = -\frac{E_s}{E_p}$$

Solution:

- Alternating current in the primary coil generates a continuously changing magnetic flux within the ferromagnetic core.
- This fluctuating flux links with the secondary coil, inducing an alternating electromotive force proportional to its turns ratio via Faraday's law.

Why other options are incorrect:

- **Option A:** Coulomb's law governs electrostatic forces between static point charges.
- **Option C:** Gas laws govern thermodynamic relationships among pressure, volume, and temperature.
- **Option D:** Hess's law governs enthalpy state summation in chemical thermodynamics.

Question #158 Key: (D)PHYSICS
13. Electronics

When the PN junction is reverse-biased, its reverse current is of the order of:

CORE CONCEPT & DERIVATION

Under reverse bias, the depletion layer widens and prevents majority carrier diffusion, permitting only a small leakage current driven by minority charge carriers.

Formula / Rule / Reaction:

$$I_0 \approx 10^{-6} \text{ A (}\mu\text{A for Germanium)} \quad \text{to} \quad 10^{-9} \text{ A (nA for Silicon)}$$

Solution:

- Connecting the positive battery terminal to the n-region and the negative terminal to the p-region attracts majority carriers away from the junction.
- Thermally generated minority carriers (electrons in p-type, holes in n-type) drift across the junction, producing a small reverse saturation current on the order of microamperes.

Why other options are incorrect:

- **Option A:** Gigaamperes (10^9 A) is an immense current that does not occur in solid-state devices.
- **Option B:** Kiloamperes (10^3 A) occurs in heavy electrical grid faults.
- **Option C:** Megaamperes (10^6 A) characterizes natural lightning discharges.

Question #159 Key: (C)PHYSICS
14. Dawn of Modern Physics

The momentum of moving photon is:

CORE CONCEPT & DERIVATION

According to quantum theory and de Broglie relations, electromagnetic radiation exhibits particle properties, carrying linear momentum inversely proportional to wavelength.

Formula / Rule / Reaction:

$$E = hf = \frac{hc}{\lambda} = pc \implies p = \frac{h}{\lambda}$$

Solution:

- Although a photon has zero invariant rest mass ($m_0 = 0$), it carries finite relativistic energy.
- Dividing photon energy (E) by the speed of light (c) yields momentum: $p = h/\lambda$.

Why other options are incorrect:

- **Option A:** mc^2 has units of energy, not momentum.
- **Option B:** λ/h is the reciprocal of linear momentum.
- **Option D:** Photons carry finite momentum, as demonstrated experimentally by radiation pressure and the Compton effect.

Question #160 Key: (A)PHYSICS
14. Dawn of Modern Physics

In every instant of time, wavelength associated with a freely falling body:

CORE CONCEPT & DERIVATION

The de Broglie matter wavelength of a moving particle is inversely proportional to its linear momentum.

Formula / Rule / Reaction:

$$\lambda = \frac{h}{p} = \frac{h}{mv} = \frac{h}{m(gt)}$$

Solution:

- A freely falling body accelerates under gravitational acceleration, increasing its velocity linearly with time ($v = gt$).
- Because linear momentum ($p = mv$) increases continuously, the associated matter wavelength λ decreases continuously.

Why other options are incorrect:

- **Option B:** Increasing wavelength would require velocity to decrease over time.
- **Option C:** A four-fold wavelength increase would require a four-fold reduction in momentum.
- **Option D:** Wavelength cannot remain constant because velocity is continually changing under gravitational acceleration.

Question #161 Key: (A)PHYSICS
14. Dawn of Modern Physics

As per 2nd photoelectric experiment, photoelectric effect does not occur if the frequency of th...

CORE CONCEPT & DERIVATION

Photoelectric emission requires incident photons to supply energy at least equal to the work function of the target metal.

Formula / Rule / Reaction:

$$K_{\max} = hf - \Phi = h(f - f_0) \quad (f \geq f_0 \text{ for emission})$$

Solution:

- The threshold frequency (f_0) is the minimum photon frequency capable of ejecting an electron from the metal surface.
- If $f < f_0$, individual photon energy is less than the work function ($hf < \Phi$), preventing photoemission regardless of beam intensity.

Why other options are incorrect:

- Option B:** When incident frequency equals threshold frequency ($f = f_0$), electrons are liberated with zero kinetic energy.
- Option C:** At three times threshold frequency, electrons are ejected with kinetic energy $K_{\max} = 2hf_0$.
- Option D:** At twice threshold frequency, electrons are ejected with kinetic energy $K_{\max} = hf_0$.

Question #162 Key: (A)PHYSICS
15. Atomic Spectra

If an electron in the hydrogen atom jumps from second to first orbit, the emitted radiation has...

CORE CONCEPT & DERIVATION

Wavelengths of spectral lines emitted during hydrogen electronic transitions are given by the Rydberg formula.

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right)$$

Solution:

- For the first line of the Lyman series, $n_1 = 1$ and $n_2 = 2$:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{1^2} - \frac{1}{2^2} \right) = R_H \left(1 - \frac{1}{4} \right) = \frac{3}{4} R_H$$

- Invert to find wavelength λ :

$$\lambda = \frac{4}{3R_H}$$

Why other options are incorrect:

- Option B:** $3/4R_H$ represents the wave number ($\bar{\nu} = 1/\lambda$), not the wavelength.
- Option C:** R_H corresponds to an uncalculated Rydberg constant factor.
- Option D:** $4R_H$ is mathematically incorrect.

Question #163 Key: (C)PHYSICS
14. Dawn of Modern Physics

Black body is an ideal radiator that radiates _____ at all wavelengths:

CORE CONCEPT & DERIVATION

An ideal black body is a theoretical physical body that acts as an ideal radiator and absorber, exhibiting maximum theoretical emissive power (emissivity $e = 1$) across all wavelengths.

Formula / Rule / Reaction:

$$e(\lambda, T) = a(\lambda, T) = 1.0 \quad (\text{Kirchhoff's Law of Thermal Radiation})$$

Solution:

- An ideal black body radiates across all wavelengths without reflection or selective transmission losses.
- In regional textbook descriptions, its status as a non-selective, ideal radiator that absorbs and radiates with equal ideal efficiency is keyed as 'equally'.

Why other options are incorrect:

- Option A:** Blackbody emission follows Planck's radiation law smoothly rather than behaving inconsistently.
- Option B:** Spectral emission forms a smooth continuous continuum rather than separate, discrete lines.
- Option D:** Although spectral radiant intensity varies with wavelength, the official syllabus rubric designates Option C based on ideal non-selective emissivity.

Question #164 Key: (B)PHYSICS
16. Nuclear Physics

Mass number A refers to:

CORE CONCEPT & DERIVATION

The mass number (A) represents the total count of nucleons (protons plus neutrons) bound within an atomic nucleus.

Formula / Rule / Reaction:

$$A = Z + N \quad (\text{Nucleons} = \text{Protons } [Z] + \text{Neutrons } [N])$$

Solution:

- Protons and neutrons reside inside the nucleus and are collectively termed nucleons.
- The mass number A is the total integer count of these nuclear particles, determining the isotopic mass.

Why other options are incorrect:

- Option A:** The count of extranuclear electrons equals the atomic number Z in a neutral atom.
- Option C:** The neutron count is given by neutron number $N = A - Z$.
- Option D:** The proton count defines the atomic number Z .

Question #165 Key: (A)PHYSICS
16. Nuclear Physics

[Formula] is a _____ constant:

CORE CONCEPT & DERIVATION

In the law of radioactive disintegration, λ denotes the decay constant (disintegration constant), representing the probability per unit time that a given nucleus will decay.

Formula / Rule / Reaction:

$$-\frac{dN}{dt} = \lambda N \implies N(t) = N_0 e^{-\lambda t}$$

Solution:

- The decay constant λ is a characteristic property of each radioisotope, with units of s^{-1} .
- It relates directly to nuclear half-life via the expression: $T_{1/2} = \frac{\ln 2}{\lambda} \approx \frac{0.693}{\lambda}$.

Why other options are incorrect:

- Option B:** Dielectric constant is designated by ϵ_r or κ .
- Option C:** Planck's constant is universally denoted by h ($6.626 \times 10^{-34} \text{ J} \cdot \text{s}$).
- Option D:** Proportionality constant is an ambiguous mathematical term, whereas decay constant is the specific physical definition.

Question #166 Key: (B)PHYSICS
16. Nuclear Physics

Gamma ray camera can observe radiations from _____ that are concentrated in the organs:

CORE CONCEPT & DERIVATION

A gamma camera (scintillation camera) detects penetrating gamma photons emitted by administered radioactive isotopes (radiotracers) to produce functional medical images.

Formula / Rule / Reaction:

Target Tissue Accumulation $\rightarrow$ Radioactive Decay (e.g., ^{99m}Tc) $\xrightarrow{\gamma\text{-Emission}}$ Scintillation Detector

Solution:

- Radiopharmaceuticals labeled with gamma-emitting radioisotopes (such as Technetium-99m or Iodine-131) are administered to patients.
- These isotopes localize in specific organs, emitting gamma rays that pass through tissue and are mapped by sodium iodide scintillation crystals in the camera.

Why other options are incorrect:

- Option A:** Stable atoms do not emit spontaneous diagnostic gamma radiation.
- Option C:** Nucleons are nuclear sub-particles (protons and neutrons) that remain bound within nuclei.
- Option D:** Free neutrons are not the detected imaging emission.

Question #167 Key: (D)PHYSICS
04. Rotational & Circular Motion

A car is moving in a circular path at a constant speed. What provides the necessary centripetal...

CORE CONCEPT & DERIVATION

When a vehicle negotiates an unbanked curve, the centripetal acceleration is provided by static friction acting between the tire contact patches and the road surface.

Formula / Rule / Reaction:

$$f_s = \frac{mv^2}{r} \leq \mu_s mg$$

Solution:

- A car turning along a horizontal curve requires a net force directed toward the center of curvature to change its direction of motion.
- This lateral force is provided by static friction between the rubber tires and the pavement, preventing the car from skidding tangentially outward.

Why other options are incorrect:

- Option A:** Inertia is the tendency to continue in a straight line, which opposes circular turning rather than providing inward force.
- Option B:** Mass has no self-attraction toward the center of the curve.
- Option C:** Engine power supplies forward propulsion along the tangent to overcome rolling resistance and drag.

Question #168 Key: (C)PHYSICS
02. Force & Motion

Which of the following pairs correctly matches a physical quantity with its SI unit?

CORE CONCEPT & DERIVATION

SI derived units express physical quantities through standard defined combinations of fundamental base units.

Formula / Rule / Reaction:

$$P = \frac{W}{t} \implies 1 \text{ Watt (W)} = 1 \text{ Joule per second (J/s)} = 1 \text{ kg} \cdot \text{m}^2 \cdot \text{s}^{-3}$$

Solution:

- Power is the rate of doing work or transferring energy, and its standard SI unit is the Watt (W).
- Option C correctly matches the physical quantity with its official SI unit.

Why other options are incorrect:

- Option A:** The SI unit of energy is the Joule (J); Newton is the unit of force.
- Option B:** The SI unit of force is the Newton (N); Joule is the unit of energy.
- Option D:** The SI unit of velocity is meters per second (m/s); m/s^2 is the unit of acceleration.

Question #169 Key: (B)

PHYSICS
02. Force & Motion

_____ is the natural tendency of an object to remain at rest or in motion with constant veloc...

CORE CONCEPT & DERIVATION

Inertia is the inherent property of a body that resists any change in its state of rest or uniform rectilinear motion in the absence of an external net force.

Formula / Rule / Reaction:

$$\sum \vec{F} = 0 \Rightarrow \vec{v} = \text{constant} \quad (\text{Newton's First Law of Motion})$$

Solution:

- According to Newton's first law of motion (the law of inertia), matter tends to maintain its state of motion unless acted upon by a net force.
- Mass provides the quantitative scalar measure of an object's inertia.

Why other options are incorrect:

- Option A:** Friction is a contact force that opposes relative motion between surfaces.
- Option C:** Mass is the numerical scalar measurement of inertia, whereas inertia is the physical property itself.
- Option D:** Weight is the gravitational force exerted on a mass: $W = mg$.

Question #170 Key: (A)

PHYSICS
02. Force & Motion

A car in motion hits and gets crashed into a tree trunk, what is NOT conserved?

CORE CONCEPT & DERIVATION

In a macroscopic inelastic collision, total momentum of the closed system remains conserved, whereas mechanical kinetic energy is dissipated into plastic deformation, heat, and acoustic energy.

Formula / Rule / Reaction:

$$\sum \vec{p}_{\text{initial}} = \sum \vec{p}_{\text{final}}, \quad K.E._{\text{final}} < K.E._{\text{initial}} \Rightarrow \Delta K.E. \neq 0$$

Solution:

- The total linear momentum of the combined closed system (car plus tree and Earth) is conserved during the impact.
- Because this impact is an inelastic collision, macroscopic kinetic energy is converted into metal crumpling, fracture energy, sound, and thermal dissipation, making kinetic energy alone non-conserved.

Why other options are incorrect:

- Option B:** Total momentum of the closed physical system is always conserved.
- Option C:** Momentum is conserved in the collision, so both quantities are not lost.
- Option D:** Momentum is conserved, contradicting this statement.

Question #171 Key: (C)

PHYSICS
02. Force & Motion

The vertical and horizontal component of the projectile motion are:

CORE CONCEPT & DERIVATION

Galileo's principle of superposition states that perpendicular components of motion in two dimensions act completely independently of each other.

Formula / Rule / Reaction:

$$x(t) = (v_0 \cos \theta)t, \quad y(t) = (v_0 \sin \theta)t - \frac{1}{2}gt^2$$

Solution:

- Gravitational acceleration acts exclusively downward along the vertical axis ($a_y = -g$), altering only the vertical velocity component.
- In the absence of air resistance, there is zero horizontal acceleration ($a_x = 0$), leaving the horizontal velocity component constant and independent of vertical motion.

Why other options are incorrect:

- Option A:** The components do not correlate; vertical position changes do not modify horizontal velocity.
- Option B:** The two motions are completely independent; a dropped ball and a horizontally projected ball hit the ground simultaneously from the same height.
- Option D:** They share a common time parameter, but their spatial dynamics are mechanically independent.

Question #172 Key: (A)

PHYSICS
02. Force & Motion

A ball is kicked horizontally from the top of a 10m high cliff with an initial speed of 15m/s. ...

CORE CONCEPT & DERIVATION

In horizontal projectile motion, horizontal velocity remains constant, while vertical velocity increases linearly under downward gravitational acceleration.

Formula / Rule / Reaction:

$$v_x(t) = v_{0x}, \quad v_y(t) = v_{0y} + gt = 0 + gt$$

Solution:

- Horizontal velocity has no acceleration, remaining constant at $v_x = 15 \text{ m/s}$.
- Vertical velocity after $t = 2 \text{ s}$ (using standard $g \approx 10 \text{ m/s}^2$):
$$v_y = (10 \text{ m/s}^2) \times (2 \text{ s}) = 20 \text{ m/s downwards}$$
- Thus, horizontal velocity is 15 m/s and vertical velocity is 20 m/s downwards.

Why other options are incorrect:

- Option B:** Vertical velocity after 2 seconds is 20 m/s, not 15 m/s.
- Option C:** Horizontal velocity remains constant at 15 m/s rather than increasing to 30 m/s.
- Option D:** Vertical velocity is zero only at the instant of release ($t = 0$).

Question #173 Key: (B)PHYSICS
03. Work & Energy

How does an angle between the force applied and the direction of motion influence the work done...

CORE CONCEPT & DERIVATION

Mechanical work is the scalar dot product of the force and displacement vectors, modulated by the cosine of the angle between them.

Formula / Rule / Reaction:

$$W = \vec{F} \cdot \vec{d} = Fd \cos \theta$$

Solution:

- The cosine function reaches its maximum positive value of +1 when $\theta = 0^\circ$.
- Applying force parallel to displacement produces maximum mechanical work:
 $W_{\max} = Fd$.

Why other options are incorrect:

- Option A:** Work varies continuously with the angle between 0 and 180 degrees via $\cos \theta$.
- Option C:** When $\theta = 90^\circ$, $\cos 90^\circ = 0$, meaning work is zero, not negative.
- Option D:** When $\theta = 45^\circ$, $W = Fd \cos 45^\circ = 0.707Fd \neq 0$.

Question #174 Key: (D)PHYSICS
03. Work & Energy

A nurse is pushing a wheelchair with an 80kg patient sitting on it. How much work is done by th...

CORE CONCEPT & DERIVATION

When the applied force acts perpendicular to the direction of motion, zero mechanical work is performed by that force.

Formula / Rule / Reaction:

$$W = F_p d \cos \theta = (mg)d \cos 90^\circ = 0$$

Solution:

- The patient's gravitational weight acts vertically downward toward the center of the Earth.
- The wheelchair moves horizontally along the floor, making the angle between force and displacement $\theta = 90^\circ$.
- Because $\cos 90^\circ = 0$, the gravitational weight does zero mechanical work.

Why other options are incorrect:

- Option A:** The weight performs no fraction of the displacement work.
- Option B:** Maximum work requires force to act parallel to displacement ($\theta = 0^\circ$).
- Option C:** Minimum work in scalar physics is zero work when perpendicular.

Question #175 Key: (D)PHYSICS
03. Work & Energy

If a constant force of 10N is applied to move an object 5m in the direction of the force, what ...

CORE CONCEPT & DERIVATION

Work performed by a constant force acting in the direction of linear displacement equals the product of force magnitude and displacement distance.

Formula / Rule / Reaction:

$$W = Fd \cos \theta = F \times d \quad (\text{for } \theta = 0^\circ, \cos 0^\circ = 1)$$

Solution:

- Substitute the given values into the work formula:
- $W = (10 \text{ N}) \times (5 \text{ m}) \times \cos 0^\circ = 50 \text{ Joules}$

Why other options are incorrect:

- Option A:** 2 J results from dividing force by distance (10 / 5).
- Option B:** 5 J results from subtracting displacement from force.
- Option C:** 15 J results from adding force and displacement.

Question #176 Key: (C)PHYSICS
02. Force & Motion

The escape velocity of a body in the gravitational field of Earth is dependent on:

CORE CONCEPT & DERIVATION

Escape velocity from a celestial body depends on the mass and radius of the planet, and is independent of the mass of the projectile or its launch angle.

Formula / Rule / Reaction:

$$v_{\text{esc}} = \sqrt{\frac{2GM_{\text{Earth}}}{R_{\text{Earth}}}}$$

Solution:

- Equating initial kinetic energy to gravitational potential energy reveals that projectile mass m cancels from both sides.
- Escape velocity depends exclusively on the gravitational constant G , the mass of the Earth M , and the orbital radius R .

Why other options are incorrect:

- Option A:** Gravitational potential is a scalar field, making escape speed independent of launch direction (neglecting atmospheric drag and planetary rotation).
- Option B:** Projectile mass cancels, and launch angle does not affect the required escape speed.
- Option D:** Escape speed is independent of the mass of the escaping body.

Question #177 Key: (D)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Choose the sentence with the correct tense and sentence structure:

CORE CONCEPT & DERIVATION

When a longer, ongoing past background activity is interrupted by a shorter discrete event, the ongoing activity uses the past continuous tense and the interrupting event uses the simple past tense.

Formula / Rule / Reaction:

Past Continuous [was/were + verb-ing] + when + Simple Past [verb-ed]

Solution:

- 'They were playing football' correctly uses the past continuous to describe the ongoing past action.
- 'When it started to rain' correctly uses the simple past to describe the interrupting event.

Why other options are incorrect:

- **Option A:** Pairs present continuous 'is going' with the past time adverbial 'yesterday'.
- **Option B:** Inconsistently shifts from past perfect continuous 'had been waiting' to simple present 'arrives'.
- **Option C:** Combines future tense 'will finish' with past tense 'went'.

Question #178 Key: (C)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct sentence:

CORE CONCEPT & DERIVATION

In complex narrative sentences describing an interruption, an ongoing past action requires the past continuous tense while the interrupting action requires the simple past tense.

Formula / Rule / Reaction:

Past Continuous + when + Simple Past

Solution:

- The ongoing background action is correctly rendered as 'was talking'.
- The interrupting event is correctly expressed using the past tense verb 'fell'.

Why other options are incorrect:

- **Option A:** Uses the present tense verb 'fall' to describe an interruption in a past continuous frame.
- **Option B:** Uses present continuous 'is talking' with present 'fall' to narrate a completed past accident.
- **Option D:** Uses the present continuous 'am falling' within a past continuous clause.

Question #179 Key: (C)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Choose the correct sentence:

CORE CONCEPT & DERIVATION

In negative past simple sentences using the auxiliary verb 'did not' (didn't), the main lexical verb must appear in its uninflected base infinitive form.

Formula / Rule / Reaction:

Subject + did not (didn't) + Base Form of Verb (V1)

Solution:

- Because the auxiliary 'didn't' already marks the past tense, the main verb must remain in its base form 'know'.
- 'She didn't know about the surprise party' follows standard grammatical negation.

Why other options are incorrect:

- **Option A:** Erroneously combines the past auxiliary 'didn't' with the past tense verb form 'knew' (double past marking).
- **Option B:** Uses past tense 'knew' after the auxiliary 'hasn't' instead of the past participle 'known'.
- **Option D:** Incorrectly attaches the past tense form 'knew' to the present auxiliary 'doesn't'.

Question #180 Key: (C)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

After she _____ the stairs, her heart almost gave out from exhaustion.

CORE CONCEPT & DERIVATION

When two past actions occur sequentially, the earlier completed action is expressed using the past perfect tense ('had' + past participle).

Formula / Rule / Reaction:

After + Past Perfect (had + V3), Simple Past (V2)

Solution:

- Climbing the stairs was completed before her heart gave out.
- The earlier action requires the past perfect auxiliary: 'had climbed'.

Why other options are incorrect:

- **Option A:** Present perfect 'has climbed' is inconsistent with the simple past main verb 'gave out'.
- **Option B:** 'Have climbed' uses plural agreement with a singular subject ('she') and clashes with the past frame.
- **Option D:** 'Was climbing' implies the action was ongoing at the moment her heart gave out, whereas 'after' indicates completion.

Question #181 **Key: (B)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Punctuate the given sentence correctly: The teacher asked did you complete your homework

CORE CONCEPT & DERIVATION

Direct speech must be set off by a comma, enclosed within quotation marks, begin with a capital letter, and retain terminal question punctuation inside the quotation marks.

Formula / Rule / Reaction:

Reporting Clause + comma + "Capitalized Direct Question?"

Solution:

- The reporting clause ('The teacher asked') is followed by a comma.
- The spoken question is enclosed in double quotation marks with its initial word capitalized ('Did') and terminal question mark enclosed within the quotes.

Why other options are incorrect:

- **Option A:** Fails to enclose direct quoted speech in quotation marks.
- **Option C:** Lacks capitalization on the initial quoted word ('did') and replaces the question mark with a period.
- **Option D:** Omits quotation marks and uses an incorrect terminal period for a question.

Question #182 **Key: (A)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Punctuate the following sentence correctly: Lets meet at Sarahs house after school

CORE CONCEPT & DERIVATION

Contractions require an apostrophe to indicate omitted letters, and singular possessive nouns require an apostrophe followed by 's'.

Formula / Rule / Reaction:

Let us → Let's (Contraction), House of Sarah → Sarah's (Possessive)

Solution:

- 'Let's' requires an apostrophe to replace the omitted letter 'u' in 'let us'.
- 'Sarah's' requires an apostrophe before 's' to indicate singular possession of the house.

Why other options are incorrect:

- **Option B:** Places the apostrophe after 's' ('Sarahs'), which incorrectly indicates plural possession.
- **Option C:** Omits the necessary contraction apostrophe in 'Lets'.
- **Option D:** Inserts an unnecessary comma between the verb 'meet' and the prepositional phrase 'at Sarah's house'.

Question #183 **Key: (D)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Do you usually take a bus..... the market?

CORE CONCEPT & DERIVATION

The preposition 'to' expresses directional movement toward an intended spatial destination or terminus.

Formula / Rule / Reaction:

Verb of Motion / Transit + to + Destination

Solution:

- The sentence inquires about vehicular transit toward a specific physical destination ('the market').
- The preposition 'to' correctly indicates destination in English syntax.

Why other options are incorrect:

- **Option A:** 'By' indicates transit means (e.g., 'by bus'), but cannot denote destination here.
- **Option B:** 'For' indicates intended purpose rather than spatial arrival at a destination.
- **Option C:** 'Of' denotes possession, origin, or composition, which is incorrect in this directional context.

Question #184 **Key: (D)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

He has been working this project for two weeks.

CORE CONCEPT & DERIVATION

The intransitive verb 'work' collocates with the preposition 'on' when referring to active engagement with a specific task, assignment, or project.

Formula / Rule / Reaction:

Work + on + Task / Project

Solution:

- Standard English idiomatically pairs 'working on' with projects and research endeavors.
- 'Working on this project' correctly describes continuous engagement over the specified two-week duration.

Why other options are incorrect:

- **Option A:** 'Working at' refers to physical employment locations (e.g., 'working at the hospital').
- **Option B:** 'Working by' denotes spatial proximity or method, not task engagement.
- **Option C:** 'Working to' indicates working toward an objective (e.g., 'working to succeed'), not project execution.

Question #185 Key: (B)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Identify the sentence that contains an **ERROR** in word order, style, or vocabulary:

CORE CONCEPT & DERIVATION

Parallel structure requires that all items coordinated in a series share the same grammatical category and syntactic form.

Formula / Rule / Reaction:

Series Consistency: Gerund, Gerund, and Gerund (V-ing, V-ing, and V-ing)

Solution:

- In Option B, the verb 'enjoys' takes two gerund direct objects ('reading', 'writing'), but shifts to a full infinitive ('to paint').
- To maintain grammatical parallelism, the series must use matching forms: 'reading, writing, and painting'.

Why other options are incorrect:

- **Option A:** 'He has a talent for solving complex problems' is grammatically correct and uses the appropriate preposition and gerund.
- **Option C:** Represents a standard pangram with correct subject-verb agreement and word order.
- **Option D:** 'They quickly adapted to the new environment' uses correct adverb placement and prepositional collocation.

Question #186 Key: (D)ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Identify the **ERROR** in the sentence: *The chef quickly prepared, delicious and it served a meal.*

CORE CONCEPT & DERIVATION

Standard English syntax requires canonical constituent ordering where verbs directly govern their coordinate conjunctions and adjectives precede noun objects.

Formula / Rule / Reaction:

Subject + Adverb + Compound Verb + Noun Phrase [Article + Adjective + Noun]

Solution:

- The original phrasing ('prepared, delicious and it served a meal') fragments clause structure with jumbled word order.
- Correct syntactic order is: 'The chef quickly prepared and served a delicious meal', making word order the error.

Why other options are incorrect:

- **Option A:** Punctuation errors stem from the underlying jumbled word order.
- **Option B:** Style refers to tone or register rather than syntactic breakdown.
- **Option C:** Individual vocabulary words are used correctly, but their sequence is disrupted.

Question #187 Key: (D)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Order is the law of civilization as chaos is the law of the _____. The most appropriate word t...

CORE CONCEPT & DERIVATION

An analogy requires semantic balance where paired concepts contrast in parallel ways across the comparison.

Formula / Rule / Reaction:

Order : Civilization :: Chaos : Wilderness

Solution:

- Civilization is characterized by human social organization, laws, and structural order.
- Its semantic opposite is the untamed wilderness, representing natural unpredictability and primal chaos.

Why other options are incorrect:

- **Option A:** 'City' is a component of human civilization that operates under social order.
- **Option B:** 'Metropolis' is a large urban center defined by organized civil laws.
- **Option C:** 'Universe' is governed by physical laws rather than contrasting directly with human civilization.

Question #188 Key: (D)ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

Blueprint is to architect as algorithm is to_____:

CORE CONCEPT & DERIVATION

This relational analogy pairs a professional with the technical plan they design to direct their work.

Formula / Rule / Reaction:

Blueprint : Architect :: Algorithm : Programmer

Solution:

- An architect designs a blueprint as a detailed technical plan to guide physical construction.
- Similarly, a computer programmer designs an algorithm as a step-by-step logical procedure to guide software execution.

Why other options are incorrect:

- **Option A:** Designers create visual sketches and graphic layouts rather than algorithms.
- **Option B:** Engineers design physical systems and machines using blueprints and schematics.
- **Option C:** Physicians diagnose and treat patients using clinical protocols, not algorithms.

Question #189 **Key: (A)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension

"Regular exercise has been shown to improve overall health by reducing the risk of chronic disease..."

CORE CONCEPT & DERIVATION

Reading comprehension inferences must be supported directly by explicit textual evidence within the passage.

Formula / Rule / Reaction:

Factual deduction / Textual comprehension.

Solution:

- The text states that people find it challenging to exercise 'due to busy schedules and a lack of motivation'.
- This directly supports the inference that busy schedules and low motivation act as barriers to regular exercise.

Why other options are incorrect:

- **Option B:** The text explicitly states that exercise reduces the risk of chronic diseases.
- **Option C:** The passage states that exercise enhances mental well-being alongside physical health.
- **Option D:** The passage states that exercise reduces stress, not that it completely eliminates all stress.

Question #190 **Key: (D)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Which of the following words is a synonym for "meticulous"?

CORE CONCEPT & DERIVATION

Synonyms are words sharing identical or closely related semantic meanings within standard English vocabulary.

Formula / Rule / Reaction:

Meticulous $\equiv$ Showing great attention to detail; careful, exacting, precise

Solution:

- 'Meticulous' describes a habit of thoroughness, precision, and close attention to detail.
- 'Precise' is its closest synonym among the choices.

Why other options are incorrect:

- **Option A:** 'Abhorrent' means inspiring disgust and loathing; repugnant.
- **Option B:** 'Heedless' means careless and unmindful, acting as an antonym to meticulous.
- **Option C:** 'Incautious' means heedless of danger; rash, which is an antonym to meticulous.

Question #191 **Key: (D)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

A person who sells goods and services is a_____:

CORE CONCEPT & DERIVATION

In economic and commercial terminology, market participants are defined by their transactional roles in the exchange of goods and services.

Formula / Rule / Reaction:

Seller of Goods / Services $\equiv$ Vendor / Merchant

Solution:

- A 'vendor' is an individual or business entity that sells items or commercial services.
- The definition directly matches the prompt.

Why other options are incorrect:

- **Option A:** A 'consumer' is an end user who buys or uses goods, not the seller.
- **Option B:** A 'purchaser' is a buyer who acquires goods through payment.
- **Option C:** A 'patron' is a customer or client who supports a business through purchases.

Question #192 **Key: (D)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The detective noticed a subtle change in the suspect's tone when he asked about his whereabouts...

CORE CONCEPT & DERIVATION

Contextual vocabulary requires determining word meaning through surrounding narrative clues.

Formula / Rule / Reaction:

Subtle $\equiv$ Fine, delicate, faint, or understated; difficult to detect

Solution:

- The suspect's tone change 'hinted at something more significant', indicating the vocal cue was faint and understated rather than obvious.
- In this context, 'subtle' is best defined as 'slight'.

Why other options are incorrect:

- **Option A:** 'Dramatic' denotes bold, striking, and conspicuous behavior, the opposite of subtle.
- **Option B:** 'Notable' means easily seen or prominent, contrasting with subtle.
- **Option C:** 'Obvious' means evident and plain, acting as a direct antonym to subtle.

Question #193 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Despite the complicated situation, she remained _____, calmly assessing her options before...

CORE CONCEPT & DERIVATION

Contextual adjective choice requires selecting a word that matches the modifying phrase ('calmly assessing her options').

Formula / Rule / Reaction:

Composed $\equiv$ Calm, collected, and in control of one's feelings

Solution:

- The sentence indicates she remained calm while assessing her choices despite difficulties.
- 'Composed' matches this calm, balanced disposition.

Why other options are incorrect:

- Option B:** 'Erratic' means unpredictable, irregular, and inconsistent.
- Option C:** 'Frantic' means wild with fear, anxiety, or panic.
- Option D:** 'Hysterical' means affected by uncontrolled extreme emotion.

Question #194 Key: (D)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Find out synonym of "Elated":

CORE CONCEPT & DERIVATION

Synonyms are words that convey the same core denotation in emotional and descriptive English vocabulary.

Formula / Rule / Reaction:

Elated $\equiv$ Exultantly proud and joyful; in high spirits; overjoyed

Solution:

- 'Elated' describes intense happiness and joy.
- 'Overjoyed' directly shares this meaning.

Why other options are incorrect:

- Option A:** 'Confused' means bewildered or unable to think clearly.
- Option B:** 'Disappointed' means sad or displeased because expectations were unmet.
- Option C:** 'Nervous' means anxious, apprehensive, or easily agitated.

Question #195 Key: (B)LOGICAL REASONING
02. Cause and Effect Analysis

Read the following statements and identify the best cause-and-effect relation: i. Sara's produc...

CORE CONCEPT & DERIVATION

In causal reasoning, an environmental disruption (the cause) produces an observable performance decline (the effect).

Formula / Rule / Reaction:

Frequent Construction Interruptions [Cause] $\implies$ Decreased Workplace Productivity [Effect]

Solution:

- Frequent auditory and environmental interruptions (Statement ii) disrupt workplace focus and flow.
- This disruption directly results in reduced workplace productivity (Statement i), establishing statement ii as the cause and statement i as the effect.

Why other options are incorrect:

- Option A:** Inverts the causal order by claiming low productivity causes external construction.
- Option C:** Assumes a prior historical timeline that is not stated in the premises.
- Option D:** Fails to recognize the clear causal link between workplace interruptions and productivity decline.

Question #196 Key: (C)LOGICAL REASONING
10. Percentages, Ratios & Unit Calculations

A store offers a 10% discount on all items. After applying the discount, the price of an item i...

CORE CONCEPT & DERIVATION

The discounted sale price equals the original base price multiplied by one minus the fractional discount rate.

Formula / Rule / Reaction:

$$\text{Discounted Price} = P_0 \times (1 - d) \implies P_0 = \frac{\text{Discounted Price}}{1 - d}$$

Solution:

- A 10 percent discount means the customer pays 90 percent of original price: $1 - 0.10 = 0.90$.
- Set up the equation:
- $0.90 \times P_0 = 450$
- Solve for original price P_0 :

$$P_0 = \frac{450}{0.90} = \text{Rs. } 500$$

Why other options are incorrect:

- Option A:** Rs. 490 with a 10% discount gives Rs. 441.
- Option B:** Rs. 495 results from mistakenly adding 10% of 450 (45) to 450, confusing the base amount.
- Option D:** Rs. 505 with a 10% discount gives Rs. 454.50.

Question #197

Key: (C)

LOGICAL REASONING

14. Direction, Distance & Spatial/Visual Patterns

I went 10m to the East from my house, then turned north and walked another 15m, and then I turn...

CORE CONCEPT & DERIVATION

Net spatial displacement is calculated by summing perpendicular vector components along cardinal Cartesian axes.

Formula / Rule / Reaction:

$$x_{\text{net}} = \sum \Delta x_i, \quad y_{\text{net}} = \sum \Delta y_i, \quad d = \sqrt{x_{\text{net}}^2 + y_{\text{net}}^2}$$

Solution:

- Set home at the origin (0, 0):
- East-West axis (x): +10 m (East) – 12 m (West) = –2 m.
- North-South axis (y): +15 m (North) – 15 m (South) = 0 m.
- The final coordinate is (–2, 0), meaning the person is 2 meters west of home:
- $d = \sqrt{(-2)^2 + 0^2} = 2 \text{ m}$

Why other options are incorrect:

- Option A:** 0 m ignores the 2-meter difference between eastward (10 m) and westward (12 m) movements.
- Option B:** 1 m is an arithmetic error.
- Option D:** 3 m overestimates net displacement.

Question #198

Key: (A)

LOGICAL REASONING

12. Linear Ranking, Ordering & Inequalities

If $a > b$, $b > c$, and $d > a$ then:

CORE CONCEPT & DERIVATION

The transitive property of mathematical inequalities allows ordered relationships to link into a single consistent chain.

Formula / Rule / Reaction:

$$d > a \text{ and } a > b \implies d > b \iff b < d$$

Solution:

- Combine the given inequalities: $d > a$, $a > b$, and $b > c$.
- This establishes the descending order: $d > a > b > c$.
- Comparing b and d , d is strictly greater than b , meaning $b < d$ is true.

Why other options are incorrect:

- Option B:** The chain shows $a > c$, contradicting $a < c$.
- Option C:** $b > d$ directly contradicts $d > b$.
- Option D:** c is the smallest element in the chain, contradicting $c > d$.

Question #199

Key: (A)

LOGICAL REASONING

07. Number Series & Numerical Progressions

Find out the missing term in the sequence: 15, 14, 12, 9, ?

CORE CONCEPT & DERIVATION

Arithmetic sequences with progressing differences subtract an integer that increases by one at each successive step.

Formula / Rule / Reaction:

$$x_n = x_{n-1} - n \quad (n = 1, 2, 3, 4, \dots)$$

Solution:

- Analyze successive differences:
- $15 - 1 = 14$
- $14 - 2 = 12$
- $12 - 3 = 9$
- The next subtraction value is 4:
- $9 - 4 = 5$

Why other options are incorrect:

- Option B:** 6 results from subtracting 3 again instead of 4.
- Option C:** 7 results from subtracting 2.
- Option D:** 8 results from subtracting 1.

Question #200

Key: (A)

LOGICAL REASONING

05. Categorical Syllogisms & Overlapping Sets

All omnivores are herbivores. No herbivores are carnivores. Some carnivores are humans. Which o...

CORE CONCEPT & DERIVATION

Formal categorical syllogisms determine conclusion validity by evaluating class inclusion and disjoint set relationships.

Formula / Rule / Reaction:

$$\text{Premises: } O \subseteq H, \quad H \cap C = \emptyset, \quad C \cap \text{Humans} \neq \emptyset$$

Solution:

- Conclusion I: Since 'Some carnivores are humans', simple set conversion confirms that 'Some humans are carnivores' is TRUE.
- Conclusion II: Since all omnivores are herbivores ($O \subseteq H$) and no herbivores are carnivores ($H \cap C = \emptyset$), omnivores and carnivores are mutually exclusive sets ($O \cap C = \emptyset$). Thus, 'No carnivores are omnivores' is TRUE.
- Conclusion III: Because omnivores and carnivores are disjoint, 'Some omnivores are carnivores' is FALSE.
- Therefore, conclusions I and II are valid.

Why other options are incorrect:

- Option B:** Includes Conclusion III, which contradicts the premises.
- Option C:** Includes Conclusion III, which is logically invalid.
- Option D:** Validates only Conclusion III, which is false.