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KMU PESHAWAR

KMU Peshawar MDCAT 2023 Official Paper

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

📍 Official Admitting Board: Khyber Medical University Peshawar 📄 Archive Code: BEAMBE-FLP-KMU-2023 ⌚ Duration: 200 Minutes (3h 20m)

200

TOTAL QUESTIONS

200m

OFFICIAL DURATION

+1 / 0.00

ZERO NEGATIVE MARKING

200

MAXIMUM MARKS

EXAMINATION BLUEPRINT & SUBJECT WEIGHTAGE

Biology**68 MCQs**

34.0% weight

Chemistry**54 MCQs**

27.0% weight

Physics**54 MCQs**

27.0% weight

English**18 MCQs**

9.0% weight

Logical Reasoning**6 MCQs**

3.0% weight

BIO SECTION: BIOLOGY

Questions 1 to 68 (68 MCQs)

Q1. BIO

Cell death due to tissue damage is called:

- (A) Necrosis
- (B) Metastasis
- (C) Apoptosis
- (D) Epistasis

Q2. BIO

Autoclave chambers are used for _____ of surgical instruments?

- (A) Sterilization
- (B) Filtration
- (C) Desiccation
- (D) Radiation

Q3. BIO

The incubation period of syphilis is:

- (A) 1–2 weeks
- (B) 2–3 weeks
- (C) 3–4 weeks
- (D) 7 days

Q4. BIO

Muscle fatigue results due to deficiency of _____ and excess accumulation of _____.

- (A) Adenosine triphosphate, lactic acid
- (B) Adenosine triphosphate, ionic imbalance
- (C) Glucose, lactic acid
- (D) Glucose, ionic imbalance

Q5. BIO

A male or female child of an affected mother has 50% chance of acquiring the disorder. Such a disorder is:

- (A) X-linked recessive disorder
- (B) X-linked dominant disorder
- (C) Y-linked dominant disorder
- (D) Y-linked recessive disorder

Q6. BIO

Which is the factory for synthesis of sugars in autotrophic eukaryotes?

- (A) Mitochondria
- (B) Ribosome
- (C) Chloroplast
- (D) Amyloplast

Q7. BIO

The co-enzyme NAD is made up of:

- (A) Vitamins
- (B) Amino acids
- (C) Nucleotides
- (D) Sugar

Q8. BIO

Storage diseases are caused by the excessive accumulation of substances within the cell, due to defects (mutations) in one of the _____ enzymes.

- (A) Amylase
- (B) Lysosomal
- (C) Lyase
- (D) Lipase

Q9. BIO

The function of the nucleolus is to form:

- (A) Nuclear envelope
- (B) Chromosome
- (C) rRNA
- (D) Cytoplasm

Q10. BIO

A shallow groove in cerebrum is called _____ and deep groove is called _____.

- (A) Sulcus, Fissure
- (B) Fissure, Sulcus
- (C) Gyrus, Fissure
- (D) Fissure, Gyrus

Q11. BIO

What brings the membrane potential to threshold?

- (A) Influx of sodium ions across the postsynaptic membrane
- (B) Outflow of sodium ions across the postsynaptic membrane
- (C) Outflow of calcium ions across the postsynaptic membrane
- (D) Influx of potassium ions across the postsynaptic membrane

Q12. BIO

What alters the shape of enzymes and makes them functional?

- (A) Cofactors
- (B) Other enzymes
- (C) Proteins
- (D) Both A and C

Q13. BIO

Which of the following is known as the vessels of the vessels?

- (A) Vasa vasorum
- (B) Tunica media
- (C) Tunica externa
- (D) Tunica interna

Q14. BIO

Which of the following is true about the occurrence of erythroblastosis foetalis?

- (A) Occurs when both father and mother are Rh positive
- (B) Occurs when both father and mother are Rh negative
- (C) Occurs when mother is Rh positive and father is Rh negative
- (D) Occurs when mother is Rh negative and father is Rh positive

Q15. BIO

All are properties of water except:

- (A) Universal solvent
- (B) Polar nature
- (C) Hydrogen bonding
- (D) Becomes denser when it freezes

Q16. BIO

Thymus gland is involved in maturation of which of the following?

- (A) Platelets
- (B) Eosinophils
- (C) B-lymphocytes
- (D) T-lymphocytes

Q17. BIO

Which component is present only in the cell wall of Gram-positive bacteria but NOT in Gram-negative bacteria?

- (A) Teichoic acids
- (B) Lipids
- (C) Peptidoglycan
- (D) Periplasmic space

Q18. BIO

In breastfeeding mothers, which hormone would be at an increased level?

- (A) Prolactin
- (B) Thyroxin
- (C) Aldosterone
- (D) Insulin

Q19. BIO

Mendel's law of independent assortment can be explained by:

- (A) Behaviour of chromosomes in mitosis
- (B) Behaviour of chromosomes in meiosis
- (C) Gene behaviour in mitosis
- (D) Both A and B

Q20. BIO

Which of the following is a rod shape virus?

- (A) Bacteriophage
- (B) Herpes virus
- (C) Hepatitis virus
- (D) Tobacco mosaic virus

Q21. BIO

Glucose is classified as a:

- (A) Monosaccharide
- (B) Disaccharide
- (C) Oligosaccharide
- (D) Polysaccharide

Q22. BIO

Which of the following is the opposite of condensation reaction?

- (A) Decarboxylation
- (B) Hydration
- (C) Dehydration
- (D) Hydrolysis

Q23. BIO

The cells of the non-virulent strain of *Streptococcus pneumoniae* are:

- (A) Capsulated and S-Type
- (B) Non-capsulated and S-Type
- (C) Capsulated and R-Type
- (D) Non-capsulated and R-Type

Q24. BIO

The total number of cranial nerves in the human body is:

- (A) 12 pairs
- (B) 24 pairs
- (C) 31 pairs
- (D) 62 pairs

Q25. BIO

Enzymes are:

- (A) Carbohydrates
- (B) Proteins
- (C) Lipids
- (D) Can be lipid or proteins

Q26. BIO

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

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

Q27. BIO

Cytotoxic T-Cells:

- (A) Directly kill invaders
- (B) Aid B cells in their job
- (C) Both A and B
- (D) Suppress T cell activity

Q28. BIO

A bacterium with single polar flagellum is:

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

Q29. BIO

The genome of the Human Immunodeficiency Virus (HIV) is made up of:

- (A) cDNA
- (B) DNA
- (C) RNA
- (D) rRNA

Q30. BIO

Hip joint and shoulder joint are examples of:

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

Q31. BIO

Locus of a gene on a chromosome means its:

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

Q32. BIO

The carotenoids absorb light in the visible spectrum between _____ and _____ wavelengths.

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

Q33. BIO

The cells of the endoderm of Coelenterates are specialised for:

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

Q34. BIO

Viruses are not classified based on:

- (A) Morphology
- (B) Host specificity
- (C) Cell membrane
- (D) Envelope

Q35. BIO

An additional covering surrounds the cell wall of some bacteria that either prevents the bacteria from being phagocytosed by host cells or helps them to make biofilm.

Which of the following term is used for this covering?

- (A) Capsule
- (B) Slime
- (C) Glycocalyx
- (D) Spore

Q36. BIO

The protein coat surrounding the genome of virus is called:

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

Q37. BIO

In the 'non-cyclic electron transport of light reaction', the deficit of ___ electrons occur in the chlorophyll, as it absorbs energy

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

Q38. BIO

What is the number of carbon atoms in pyruvic acid?

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

Q39. BIO

Sucrose is hydrolysed into:

- (A) Lactose and Glucose
- (B) Lactose and Fructose
- (C) Glucose and fructose
- (D) Glucose and galactose

Q40. BIO

_____ is the heat required to convert a gram of water into vapours at its boiling point.

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

Q41. BIO

Which mode of genetic exchange between bacteria involves cell-to-cell contact between the bacterial cells?

- (A) Transduction
- (B) Transformation
- (C) Conjugation
- (D) Both A and B

Q42. BIO

_____ regulates the selective permeability of the plasma membrane, allowing movement of molecules according to the needs of the cells.

- (A) Membrane proteins
- (B) Membrane carbohydrates
- (C) Membrane glycolipids
- (D) Membrane cholesterol

Q43. BIO

The neuron is said to be polarized when the:

- (A) Inside the plasma membrane has a negative energy compared to the outside
- (B) Inside of the plasma membrane has a positive energy compared to the outside
- (C) Inside the plasma membrane has the same energy compared to the outside
- (D) Positive charge moves inside the neuron

Q44. BIO

Which part of the brain plays a key role in long-term memory?

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

Q45. BIO

Which of the following is an example of hydrolase:

- (A) Transmethylase
- (B) Oxygenase
- (C) Peroxidases
- (D) Phosphatase

Q46. BIO

All of the following are true about neutrophils, EXCEPT:

- (A) Most abundant form of WBC's
- (B) Have a short life span.
- (C) Made by the thymus gland.
- (D) Released by the bone marrow.

Q47. BIO

According to Neo-Darwinism, which of the following is a case of evolution?

- (A) Reproductive isolation
- (B) Infinite large population
- (C) Environmental stability
- (D) Both a and b

Q48. BIO

Darwin's "Origin of species by natural selection" is mainly concerned with:

- (A) Origin of life
- (B) Adaptation
- (C) Extinction
- (D) Speciation

Q49. BIO

The sinoatrial node is located in the _____ wall of the right atrium.

- (A) Lower dorsal
- (B) Upper dorsal
- (C) On the interatrial septum
- (D) Near the coronary sinus

Q50. BIO

Where does the Trachea lie in relation to the esophagus?

- (A) Dorsal
- (B) Ventral
- (C) Medial
- (D) Lateral

Q51. BIO

Which of the following is true about bradykinin?

- (A) It is produced at the site of tissue injury.
- (B) It has no role in the leakage of fluids into the tissues in inflammation.
- (C) It destroys phagocytes.
- (D) It produces interferon gamma.

Q52. BIO

Which of the following is a prokaryote?

- (A) Protista
- (B) E. coli
- (C) Amoeba
- (D) Fungi

Q53. BIO

Endospore formation is:

- (A) A reproductive process
- (B) A vegetative process
- (C) Can be reproductive or vegetative depending on the conditions
- (D) Is related to invading host cells

Q54. BIO

Which among the following is NOT the role of Sertoli cells?

- (A) Protect sperms
- (B) Provides liquid medium to sperms
- (C) Provides nourishment to sperms
- (D) Secrete testosterone

Q55. BIO

At the beginning of the menstrual phase the _____ are at the lowest level.

- (A) Follicle stimulating hormone
- (B) Gonadotrophins
- (C) Ovarian hormones
- (D) None of these

Q56. BIO

Which cartilage is found at the end of long bones?

- (A) Calcified
- (B) Elastic
- (C) Fibrous
- (D) Hyaline

Q57. BIO

How many actin filaments surround the myosin at each end?

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

Q58. BIO

When are Rh antibodies produced in Rh-ve persons?

- (A) Naturally before birth
- (B) Naturally after birth
- (C) After exposure to Rh antigen
- (D) After exposure to Rh antibodies

Q59. BIO

Which of the following types of Haemophilia is more common in the human population?

- (A) Haemophilia A
- (B) Haemophilia B
- (C) Haemophilia C
- (D) Haemophilia VII

Q60. BIO

Parazoa are simple multicellular animals which are believed to have evolved from?

- (A) Bacteria
- (B) Protists
- (C) Fungi
- (D) Plants

Q61. BIO

Which structure is responsible for the excretion in Arthropods?

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

Q62. BIO

Alternation of generation is the character of ____ phylum?

- (A) Arthropoda
- (B) Annelida
- (C) Coelenterata
- (D) Echinodermata

Q63. BIO

Which of the following can be effective in preventing viral infection in humans?

- (A) Taking antihistamines
- (B) Getting vaccinated
- (C) Applying antiseptics
- (D) Taking antibiotics

Q64. BIO

Purines are _____ nitrogenous bases.

- (A) Double ringed
- (B) Single ringed
- (C) Double bond
- (D) Single bond

Q65. BIO

What is 'Flavin adenine dinucleotide'?

- (A) Catalyst
- (B) Coenzyme
- (C) Cofactor
- (D) Enzyme

Q66. BIO

The cerebellum is primarily concerned with:

- (A) Thinking and reasoning
- (B) Balancing during active movement
- (C) Temperature regulation
- (D) Initiation of muscular contraction

Q67. BIO

Adding substrates will NOT make a difference to the enzyme catalysed reaction:

- (A) When few enzyme molecules are left unsaturated.
- (B) When the substrate cools down.
- (C) When the substrate heats up.
- (D) When many enzyme molecules remain unsaturated.

Q68. BIO

All animals begin life as a _____.

- (A) Multicellular fertilised egg
- (B) Single fertilised egg
- (C) Hollow blastula
- (D) Gastrula

CHEM SECTION: CHEMISTRY

Questions 69 to 122 (54 MCQs)

Q69. CHEM

X is a compound that do not react with Na metal but produces carboxylic acid when heated under reflux with acidified potassium dichromate?

- (A) Propanal
- (B) Propanone
- (C) Propan-1-ol
- (D) Propan-2-ol

Q70. CHEM

Which reaction will proceed in forward direction?

- (A) $K_c=10$
- (B) $K_c=1$
- (C) $K_c=1/10$
- (D) $K_c=1/100$

Q71. CHEM

Which pair of ions have five unpaired d-electrons?

- (A) Fe^{+2} and Mn^{+2}
- (B) Fe^{+2} and Mn^{+3}
- (C) Fe^{+3} and Mn^{+3}
- (D) Fe^{+3} and Mn^{+2}

Q72. CHEM

Which one the following is a Nucleophile.

- (A) H_2O
- (B) $AlCl_3$
- (C) BF_3
- (D) Cl_2

Q73. CHEM

Which one is more metallic?

- (A) Na
- (B) Mg
- (C) Cs
- (D) K

Q74. CHEM

Which of the following spectral lines series lies in the visible Region?

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

Q75. CHEM

Which of the following represents the functional group of acid halides?

- (A) $R-OH$
- (B) $R-COX$
- (C) $R-X$
- (D) $R-COOH$

Q76. CHEM

Which of the following prefixes is used when two methyl groups are attached with the second last carbon of alkane chain?

- (A) n-
- (B) iso-
- (C) neo-
- (D) geminal-

Q77. CHEM

Which of the following organic acid does NOT have a $COOH$ group?

- (A) Acetic acid
- (B) Ascorbic acid
- (C) Butyric acid
- (D) Picric acid

Q78. CHEM

Which of the following cell reactions correctly represent the electrolysis of water?

- (A) $2H^+ + 2e^- \rightarrow H_2(g)$
- (B) $2H_2O + 2e^- \rightarrow H_2(g) + 2(OH^-)$
- (C) $2(OH^-) \rightarrow 2H_2O + O_2(g) + 4e^-$
- (D) $2H_2O \rightarrow O_2(g) + 4H^+ + 4e^-$

Q79. CHEM

Which method is generally used to prepare alkynes?

- (A) Dehydrohalogenation of vicinal dihalide
- (B) Hydrogenation of alkene
- (C) Hydrolysis
- (D) Hydration of alkene

Q80. CHEM

Which compound is formed when Magnesium is reacted with 2 molecules of water?

- (A) $Mg(OH)_2$
- (B) $Mg(OH)$
- (C) MOH
- (D) $Mg(OH)_3$

Q81. CHEM

When an element occurs in different physical forms it is called

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

Q82. CHEM

What mass of $CaCO_3$ gives 48.8 litres (measured at STP) of CO_2 , on strong heating?

- (A) 100g
- (B) 150g
- (C) 200g
- (D) 300g

Q83. CHEM

What is the reason of small atomic radii of sodium ions as compared to sodium atom?

- (A) Electronegativity
- (B) Effective nuclear charge
- (C) Shielding effect
- (D) Electron affinity

Q84. CHEM

What is the radius of 3rd orbit of electron in H- atom.

- (A) 3.39A
- (B) 4.761A
- (C) $5.29 \times 10^{-11} \text{A}$
- (D) 9.7A

Q85. CHEM

What is the other name for Positive rays?

- (A) Canal rays
- (B) Magnetic rays
- (C) Quantum
- (D) Photon rays

Q86. CHEM

The Volume of a fixed mass of gas is directly proportional to absolute temperature and constant pressure as stated by:

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

Q87. CHEM

The tautomer of propenol is

- (A) Propanal
- (B) Propanone
- (C) Methyl ethyl ether
- (D) Butanone

Q88. CHEM

The substituent attached to the benzene ring that act as Ring deactivator is.

- (A) NO₂
- (B) COOH
- (C) Cl
- (D) NH₃

Q89. CHEM

The specific heat of water is.

- (A) 4.2 kJ/mol/K
- (B) 4.2 J/g.K
- (C) 4.61/g/K
- (D) 42/g/K

Q90. CHEM

The SI unit of pressure is.

- (A) Pascal
- (B) mmHg
- (C) torr
- (D) atm

Q91. CHEM

The reactant which consumes first in a chemical reaction is called?

- (A) Consumed reactant
- (B) Limiting reactant
- (C) Excess reactant
- (D) Non-reacted reactant

Q92. CHEM

The number of particles (atoms, molecules, tons) in one mole of any substance is numerically equal to

- (A) 6.023×10^{22}
- (B) 6.023×10^{21}
- (C) 6.023×10^{23}
- (D) 4.02×10^{23}

Q93. CHEM

The final substitution product in the Chlorination of methane in the presence of UV light and excess chlorine is.

- (A) Methylene chloride
- (B) Carbon tetrachloride
- (C) Methylene dichloride
- (D) Chloroform

Q94. CHEM

The element chlorine is found in a gaseous state while bromine is found in:

- (A) Solid state
- (B) Liquid state
- (C) Crystalline form
- (D) Condensed form

Q95. CHEM

The correct sequence according to acidity of alcohols is.

- (A) Primary > Secondary > Tertiary.
- (B) Tertiary > Secondary > Primary
- (C) Secondary > Primary > Tertiary
- (D) Primary < Secondary < Tertiary

Q96. CHEM

The correct order of reactivity of alkyl halides is.

- (A) R-Br > R-Cl > R-F > R-I
- (B) R-Br > R-F > R-I > R-Cl
- (C) R-I > R-Br > R-Cl > R-F
- (D) R-Cl > R-I > R-Br > R-F

Q97. CHEM

The bond that determines the secondary structure of protein is:

- (A) Coordinate bond
- (B) Covalent bond
- (C) Hydrogen bond
- (D) Ionic bond

Q98. CHEM

Super batteries with high charge density are also called:

- (A) Primary batteries
- (B) Secondary batteries
- (C) Solar batteries
- (D) Fuel batteries

Q99. CHEM

Silver Mirror with Tollens Reagent is formed by

- (A) Acid halides
- (B) Alcohols
- (C) Aldehydes
- (D) Ketones

Q100. CHEM

Select the correct IUPAC name among the following:

- (A) 2-Bromo-4-chloro-3-iodopentane
- (B) 4-Bromo-2-chloro-3-iodopentane
- (C) 4-Bromo-2-iodo-3-chloropentane
- (D) 2-Chloro-3-iodo-4-bromopentane

Q101. CHEM

Oxidation of Secondary alcohol gives which of the following products?

- (A) Aldehydes
- (B) Carboxylic acids
- (C) Ester
- (D) Ketone

Q102. CHEM

One molecule of oxygen has the same mass as:

- (A) 8 moles of O₂
- (B) 16 moles of H
- (C) 2 molecules of CH₄
- (D) One atom of Sulphur

Q103. CHEM

Lucas test is based on?

- (A) Order of reaction
- (B) Condition of reaction
- (C) Molecularity of reaction
- (D) Rate of reaction

Q104. CHEM

Increasing the compressibility of a gas (Z) decreases its.

- (A) Pressure
- (B) Volume
- (C) Temperature
- (D) Concentration

Q105. CHEM

In the IUPAC system Carboxylic acid is also called _____

- (A) Amino acid
- (B) Alkanoic acid
- (C) Alkenoic acid
- (D) Alkyl alkanoate

Q106. CHEM

The Wolff-Kishner reduction is carried out under which conditions?

- (A) Acidic
- (B) Basic
- (C) Neutral
- (D) Anhydrous

Q107. CHEM

In following molecules which one has the shortest C-C bond length?

- (A) C₃H₈
- (B) C₂H₆
- (C) C₂H₄
- (D) C₂H₂

Q108. CHEM

In crystalline structure, when the length of all axes and angles are unequal then crystal will be.

- (A) Cubic
- (B) Monoclinic
- (C) Orthorhombic
- (D) Triclinic

Q109. CHEM

In a rate equation, rate=k[A]^a[B]^b, the reaction is

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

Q110. CHEM

If the work is done by the system on the surroundings and heat is absorbed by the system from the surroundings the change in internal energy E will be

- (A) E = q + w
- (B) E = q + (-w)
- (C) E = (-q) + (-w)
- (D) E = (-q) + w

Q111. CHEM

Humans are unable to digest:

- (A) Starch
- (B) Denatured protein
- (C) Cellulose
- (D) Fructose

Q112. CHEM

H₂O has geometry:

- (A) Regular tetrahedron
- (B) Linear
- (C) Distorted tetrahedral
- (D) Pyramidal

Q113. CHEM

Greater the resonance energy of a molecule?

- (A) Higher will be its reactivity.
- (B) Lower will be its stability
- (C) Higher will be its stability.
- (D) Higher will be its density.

Q114. CHEM

For an endothermic reaction, H represents the enthalpy of reaction. The minimum value for the energy for activation will?

- (A) Equal to ΔH
- (B) More than ΔH
- (C) Less than ΔH
- (D) Zero

Q115. CHEM

Flame tests identify alkali metals when they are burnt, which of the combinations given is the correct one?

- (A) Li: Red
- (B) Na: Lilac
- (C) K: Red
- (D) Cs: Yellow

Q116. CHEM

Enantiomers are examples of

- (A) Cis Isomers
- (B) Trans Isomers
- (C) Optical Isomers
- (D) Geometric isomers

Q117. CHEM

Compound X reacts with Grignard's reagent to produce tertiary alcohols. What is the compound?

- (A) Aldehyde
- (B) Ketone
- (C) Acid halide
- (D) Carboxylic acid

Q118. CHEM

Brass is an alloy of

- (A) Copper and Iron
- (B) Copper and Mg
- (C) Copper and Zinc
- (D) Copper and Silver

Q119. CHEM

An unknown element having electronic configuration $[\text{Ne}] 5s^2 5p^5$ will be.

- (A) Metal of II-A group
- (B) Metalloid of V-A group
- (C) Non-metal of VII-A group
- (D) Non-metal of V-A group

Q120. CHEM

Amount of heat absorbed, when one mole of liquid changes to gas at its boiling point is called:

- (A) Molar heat of sublimation
- (B) Heat of vaporisation
- (C) Latent heat of fusion
- (D) Heat capacity

Q121. CHEM

A well-known physical change is melting of ice. The melting of ice is favoured by:

- (A) Low Pressure, High Temperature
- (B) Low Temperature, High Pressure
- (C) High Temperature, High Pressure
- (D) Low Temperature, Low Pressure

Q122. CHEM

What is primary function of Grignard reagent in organic reactions?

- (A) To act as strong acid
- (B) To act as nucleophile and add to carbonyl compounds
- (C) To act as electrophile
- (D) To catalyze hydrogenation reaction

PHY SECTION: PHYSICS

Questions 123 to 176 (54 MCQs)

Q123. PHY

_____ law states that the magnitude of the force between 2-point charges is directly proportional to the product of the magnitudes of the charges and inversely proportional to the square of the distance between them.

- (A) Ohm's law
- (B) Gauss law
- (C) Coulomb's law
- (D) Lenz law

Q124. PHY

A ball thrown vertically upwards will have constant _____ and a varying _____

- (A) Velocity and acceleration
- (B) Kinetic energy, velocity
- (C) Acceleration, velocity
- (D) Kinetic energy and acceleration

Q125. PHY

A boy raises an object of mass 10Kg vertically above his head through a height of 5m. The potential energy stored in the body is: _____

- (A) 98 J
- (B) 49 J
- (C) 490 J
- (D) 980 J

Q126. PHY

A magnet is suspended from a spring and it oscillates in and out of a coil placed vertically below it. A galvanometer is connected to the coil and it shows?

- (A) No deflection
- (B) Deflection on one side only
- (C) Deflection to the left and right with constant amplitude
- (D) Deflection to the left and right with decreasing amplitude

Q127. PHY

A man standing in an elevator on the third floor of a building. What is the primary factor that determines the man's kinetic energy?

- (A) His height above the ground
- (B) His mass
- (C) Elevator's speed
- (D) Elevator's direction of movement

Q128. PHY

A resistor has a resistance of 200 ohms. If a current of 0.5 amperes flows through it, what is the voltage drop across the resistor?

- (A) 100 volts
- (B) 110 volts
- (C) 120 volts
- (D) 0.002 volts

Q129. PHY

A three-dimensional image of remarkable quality can be achieved by modern version of microscope called:

- (A) Compound microscope
- (B) Simple microscope
- (C) Transmission electron microscope
- (D) Scanning electron microscope

Q130. PHY

A train travels on a straight track passing signal A at 20 m/s. It accelerates uniformly at 2 m/s^2 and reaches signal B 100m further than A. At B the velocity of the train in m/s is

- (A) 10
- (B) 20
- (C) 28
- (D) 56

Q131. PHY

A wave is characterised by the physical parameters:

- (A) Amplitude, wavelength and acceleration
- (B) Frequency, wavelength and acceleration
- (C) Wavelength, frequency and speed of wave
- (D) Displacement, wavelength and speed of wave

Q132. PHY

Accelerating electromagnetic charges radiate electromagnetic waves which propagate at the

- (A) speed of electromagnetic waves
- (B) Frequency of light
- (C) speed of light
- (D) Frequency of electromagnetic waves

Q133. PHY

K- α rays are generated when transition of an electron occurs from:

- (A) K to M shell
- (B) N to K shell
- (C) L to K shell
- (D) M to L shell

Q134. PHY

The decay constant of sodium (Na) is 0.0000128 /s . The half-life of sodium is:

- (A) 15 hrs
- (B) 16 hrs
- (C) 900 s
- (D) 3600 s

Q135. PHY

At the end of 14 min, $1/16$ of a sample of radioactive Polonium remains. The corresponding half-life is:

- (A) $(7/8) \text{ min}$
- (B) $(8/7) \text{ min}$
- (C) $(7/4) \text{ min}$
- (D) $(7/2) \text{ min}$

Q136. PHY

According to Bohr's model of the hydrogen atom, electrons move in specific orbits around the nucleus called.

- (A) Quanta
- (B) Shell
- (C) Clouds
- (D) Wavelengths

Q137. PHY

According to first law of thermodynamics, what is the relationship between the change in the internal energy of a closed system ΔU , the heat added to the system (Q) and the work done by the system W .

- (A) $\Delta U = Q + W$
- (B) $\Delta U = Q - W$
- (C) $\Delta U = Q \cdot W$
- (D) $\Delta U = Q/W$

Q138. PHY

Angular displacement is measured in

- (A) Degree
- (B) Revolutions
- (C) Radians
- (D) All

Q139. PHY

Centrifugal force =

- (A) mv^2/r
- (B) m^2v/r
- (C) mv/r^2
- (D) mv^2/r

Q140. PHY

Circular periodic waves can be generated

- (A) In a ripple tank using spherical dippers
- (B) Using electromagnetic vibrator
- (C) By giving sudden up and down movement to a rope with one fixed end
- (D) All of the above

Q141. PHY

If a moving object has no force acting on it.

- (A) It will decelerate and eventually stop
- (B) Continue to move in a straight line at constant velocity
- (C) It will stop immediately
- (D) Its velocity will increase while moving in a straight line

Q142. PHY

If the acceleration of a body in one inertial frame is zero, its acceleration in any other inertial frames is

- (A) Increased
- (B) Zero
- (C) Decreased
- (D) Increased and then decreased

Q143. PHY

If the amount of work W is required to move a charge Q from one point to another then the potential difference between the two points is given by

- (A) $V = W/Q$
- (B) $V = Q/W$
- (C) $Q = W/V$
- (D) $Q = V/W$

Q144. PHY

A photon while passing through a magnetic field is deflected towards:

- (A) North pole
- (B) Are ionized
- (C) South pole
- (D) None of these

Q145. PHY

In special theory of relativity, the law of conservation of energy and law of conservation of mass have been replaced with

- (A) The law of conservation of mass only
- (B) Law of conservation of mass-energy
- (C) law of conservation of energy only
- (D) All of the above

Q146. PHY

In three dimensional Cartesian Coordinate system (x, y, z) , you have two vectors A and B . Vector A has components $A_x = 4$, $A_y = 3$, and $A_z = 2$, while vector B has components $B_x = 1$, $B_y = 5$, and $B_z = 2$. What is dot (scalar product) of vectors A and B ?

- (A) 23
- (B) -23
- (C) 0
- (D) 19

Q147. PHY

In case of doppler effect, the apparent frequency will be _____ the actual frequency when the source moves towards the stationary observer

- (A) less than
- (B) more than
- (C) equal to
- (D) none of these

Q148. PHY

Magnetic flux is maximum when the angle between the magnetic field and the normal to the plane of finite area is

- (A) Zero degree
- (B) 90 degree
- (C) 60 degree
- (D) 30 degree

Q149. PHY

Measure of displacement covered with passage of time is called.

- (A) Acceleration
- (B) speed
- (C) velocity
- (D) Deceleration

Q150. PHY

Newton's 3rd law of motion is correlated with

- (A) law of conservation of energy
- (B) momentum
- (C) law of conservation of velocity
- (D) All

Q151. PHY

Ohm's law states that the current is directly proportional to _____ and inversely proportional to _____

- (A) resistance, current
- (B) resistance, voltage
- (C) voltage, current
- (D) voltage, resistance

Q152. PHY

The ability to produce an electromotive force by changing the magnetic field inside a coil is used to generate.

- (A) mechanical energy
- (B) electricity
- (C) electromagnetic force
- (D) magnetic energy only

Q153. PHY

The absolute potential energy of a spaceship on the surface of the earth is:

- (A) $GmMe/Re^2$
- (B) $GmMe/Re$
- (C) $GmMe/2Re$
- (D) $-GmMe/Re$

Q154. PHY

The bird perching on a high-power line does not get electroshock. This is because.

- (A) The whole body of the bird sitting on the live wire is at the same potential and hence no current flows through the body
- (B) The whole body of the bird sitting on the live wire is at zero potential and hence no current flows through the body
- (C) Because the air medium between the live wire and the earth contains large numbers of charged particles
- (D) Because the air medium between the live wire and the earth contains large number of electrons

Q155. PHY

The capacitance of capacitor depends upon

- (A) area of the plates
- (B) distance between the plates
- (C) dielectric between them
- (D) All

Q156. PHY

The Compton's effect is the phenomenon that describes

- (A) The scattering of the light by prism
- (B) The bending of light when it passes from one medium to another
- (C) The change in the wavelength of X-rays when they interact with matter
- (D) The creation of interference patterns in a double-slit experiment

Q157. PHY

The current produced by a generator is called

- (A) Direct current
- (B) Pulsating current
- (C) Alternating current
- (D) Variable current

Q158. PHY

The device used to adjust voltage levels in an electrical circuit is called

- (A) Voltage regulator
- (B) Circuit Breaker
- (C) Capacitor
- (D) Transformer

Q159. PHY

The distance covered by sound wave per unit time is called

- (A) Speed of sound wave
- (B) Velocity of sound wave
- (C) Wavelength of sound wave
- (D) Amplitude of sound wave

Q160. PHY

The domestic electricity supply has a frequency of

- (A) 150Hz
- (B) 50Hz
- (C) 100Hz
- (D) 200Hz

Q161. PHY

The instantaneous power supplied to a circuit is a product of the _____ and _____.

- (A) Instantaneous current, instantaneous voltage
- (B) Instantaneous power, instantaneous voltage
- (C) instantaneous voltage, instantaneous conductance
- (D) Instantaneous current, instantaneous power

Q162. PHY

The number of waves passing through a certain point in unit time is called.

- (A) Wave speed
- (B) Time period
- (C) Wavelength of waves
- (D) Frequency of waves

Q163. PHY

The primary purpose of rectification in an electrical circuit is to

- (A) Convert Direct current (DC) into Alternating current (AC)
- (B) Smooth out voltage fluctuations
- (C) Convert AC to DC by allowing current to flow in one direction
- (D) Amplify electrical signals

Q164. PHY

The radial acceleration is also considered as:

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

Q165. PHY

The resistance of the conducting material depends upon

- (A) The nature of the conductor
- (B) Dimension of the conductor
- (C) Physical state of the conductor
- (D) All

Q166. PHY

The SI unit of capacitance is

- (A) Watts
- (B) Henry
- (C) Farads
- (D) Joules

Q167. PHY

The SI unit of electric potential is:

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

Q168. PHY

The thermal energy required to cause a unit temperature rise is called

- (A) Heat Capacity
- (B) Heat Volume
- (C) Heat Conductor
- (D) Heat energy/ unit volume

Q169. PHY

The waves in which the particles of the medium vibrate about their mean position along the direction of propagation of the waves are called

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

Q170. PHY

There are 2 pianos playing the same note, however the vibration from one piano is 223.20 Hz and that of the other is 223.50 Hz.

The beat frequency between the two tones will be?

- (A) 0.3 Hz
- (B) -0.3 Hz
- (C) 0 Hz
- (D) 223.35 Hz

Q171. PHY

Weber is the unit of

- (A) Electric potential
- (B) Electric intensity
- (C) Magnetic intensity
- (D) Magnetic flux

Q172. PHY

What happens to a football which is inflated in a warm room, is used to play outside in cold weather?

- (A) It will expand due to expansion of the air molecules
- (B) It will deflate due to contraction of the air molecules
- (C) Its size will not be affected by the change in temperature
- (D) It will burst.

Q173. PHY

What is the rest mass of a photon?

- (A) Zero
- (B) Equal to the mass of electron
- (C) Equal to the mass of proton
- (D) Infinite

Q174. PHY

Which of the following best describes inertia?

- (A) The force of gravity acting on an object
- (B) The resistance of an object to a change in its state of motion
- (C) The weight of an object
- (D) The acceleration of an object due to applied force

Q175. PHY

Which of the following materials have a negative temperature coefficient?

- (A) Germanium and silicon
- (B) Germanium and iron
- (C) Iron and silicon
- (D) Iron and copper

Q176. PHY

Which of the following quantities is correctly matched to its unit?

- (A) Electric charge: Ampere (A)
- (B) Current: Volt (V)
- (C) Electric power: Watt (W)
- (D) Resistance: coulomb

ENG SECTION: ENGLISH

Questions 177 to 194 (18 MCQs)

Q177. ENG

_____ going to sleep, I like to read for half an hour.

- (A) After
- (B) Before
- (C) As soon as
- (D) While

Q178. ENG

We are all looking forward _____ the announcement of election soon.

- (A) For
- (B) To
- (C) About
- (D) On

Q179. ENG

The dogs _____ escaped.

- (A) Did
- (B) Has
- (C) Had
- (D) Will

Q180. ENG

Maria _____ that she could not attend classes next week.

- (A) Told his professors
- (B) Said her professors
- (C) Told her professors
- (D) Is telling her professors

Q181. ENG

_____ you like a cup of coffee?

- (A) May
- (B) Shall
- (C) Can
- (D) Would

Q182. ENG

The synonym for "promptly" is:

- (A) Slovenly
- (B) Instantly
- (C) Diligently
- (D) Intelligently

Q183. ENG

The police _____ arrested the suspect.

- (A) Has
- (B) Have
- (C) Be
- (D) Been

Q184. ENG

Identify the part of the sentence that carries error:

How much (A) spoonfuls of sugar (B) would you like (C) in (D) your tea?

- (A) Much
- (B) Sugar
- (C) Like
- (D) In

Q185. ENG

The phrase "spiffed up" stands for:

- (A) Dressed up
- (B) Cleaned up
- (C) Upset
- (D) Fade

Q186. ENG

Read the following passage to answer the given question:

In prolonged space flight, besides the obvious hazards of meteors, rocky debris, and radiation, astronauts will have the deal with muscle atrophy brought on by weightlessness; therefore, when they return to Earth, they face a protracted period of weight training to rebuild their strength.

What is the most likely meaning of the word "debris" as it is used in this passage?

- (A) Fragments
- (B) Decay
- (C) Bacteria
- (D) Alien life

Q187. ENG

The money, property, etc that is used to start or operate a business is called?

- (A) Cost
- (B) Asset
- (C) Capital Investment
- (D) Fiscal status

Q188. ENG

The Queen of England bestowed a title upon the man who saved her life from a fatal accident.

What does the underlined word mean?

- (A) Conferred
- (B) Discard
- (C) Withdrawn
- (D) Retailled

Q189. ENG

Correct the given sentence:

I like cats, I hate dogs.

- (A) I like cats: I hate dogs
- (B) I like cats I hate dogs
- (C) I like cats' I hate dogs
- (D) I like cats but I hate dogs

Q190. ENG

Add suitable conjunction in the given sentence. Your ice cream will melt, you should eat it quickly.

- (A) Your ice cream will melt so you should eat it quickly
- (B) Your ice cream will melt however you should eat it quickly
- (C) Your ice cream will melt so that you should eat it quickly.
- (D) Your ice cream will melt, however you should eat it quickly.

Q191. ENG

choose the correct option

- (A) These scissors are very sharp.
- (B) This scissor is very sharp.
- (C) This scissors is very sharp.
- (D) These scissor are very sharp.

Q192. ENG

Choose the sentence with correct word order.

- (A) Sue took from the window the cover.
- (B) Sue cover from the window took the cover.
- (C) Sue took the cover from the window.
- (D) Sue the cover took from the window.

Q193. ENG

"To cut off the head"

This idiom means:

- (A) Defrock
- (B) Decapitate
- (C) Impaled
- (D) Urbanite

Q194. ENG

Choose the correct option.

We must _____ the tickets for the movie in advance.

- (A) Remove
- (B) Take
- (C) Draw
- (D) Buy

LOGIC SECTION: LOGICAL REASONING

Questions 195 to 200 (6 MCQs)

Q195. LOGIC

Read the paragraph carefully and answer the question given.
 "Over the past century the businessman has helped build civilization's great cities, provided people with luxuries and lifted his fellow citizens to a certain standard of living. Further seeding the industrial revolution around the world.

The paragraph best supports the statement that the businessman:

- (A) Is accountable to the society
- (B) Provides seeds to agricultural sector
- (C) Is the beneficiary of the industrial revolution
- (D) Has contributed to the growth of civilisation

Q196. LOGIC

Some months have 31 days, how many have 28?

- (A) One month and that is February
- (B) February, every 4 years
- (C) All months have 28 days
- (D) None

Q197. LOGIC

Read the following and choose the correct answer. Mice are to cats as goats are to,

- (A) Snakes
- (B) Hippos
- (C) Horses
- (D) Lions

Q198. LOGIC

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

(I) For the past four years, the district's literacy rate has been rising.

(II) The district administration organise a thorough training program for the volunteers working on the literacy campaign

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

Q199. LOGIC

Observe and the pattern and select the next term in the sequence:

P5QR, P4QS, P3QT, _____, P1QV

- (A) P2QU
- (B) PQ3U2
- (C) P2QUY
- (D) PQ3U

Q200. LOGIC

Statement: Due to increasing pollution, the government bans to use of all single-use plastic products from next years,
 "Courses of Action:

- An awareness campaign is introduced by the government to encourage people to use eco-friendly products.
- Subsidies to be provided to companies that manufacture eco-friendly products.

- (A) Only I follows
- (B) Only II follows
- (C) Neither I and II follow
- (D) Both I and II follow

OFFICIAL VERIFIED ANSWER KEY

KMU Peshawar MDCAT 2023 Official Paper - Rapid Self-Grading Grid

[Online Portal >](#)

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

SUBJECT-WISE PERFORMANCE BREAKDOWN

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

PMDC PROVINCIAL MERIT FORMULA

Official Weightage Law:

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

BIOLOGY
01. Cell

Cell death due to tissue damage is called:

CORE CONCEPT & DERIVATION

Cell death occurs primarily through two pathways: programmed physiological suicide or unprogrammed pathological death following acute injury.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Necrosis is the morphological pattern of pathological cell death that occurs when cells are exposed to severe trauma, hypoxia, hyperthermia, or chemical poisons.
- It is characterized by cell swelling, rupture of the plasma membrane, enzymatic digestion of cellular components, and leakage of intracellular contents into surrounding tissues, triggering an inflammatory reaction.

Why other options are incorrect:

- **Option B:** Metastasis is the dissemination of malignant neoplastic cells from their primary site of origin to distant, non-contiguous anatomical locations.
- **Option C:** Apoptosis is programmed, energy-dependent cell death characterized by cell shrinkage, chromatin condensation, membrane blebbing, and phagocytosis without an inflammatory response.
- **Option D:** Epistasis is a genetic phenomenon wherein the phenotypic expression of one gene locus masks or alters the phenotypic expression of an entirely separate gene locus.

Question #2 Key: (A)

BIOLOGY
10. Homeostasis

Autoclave chambers are used for _____ of surgical instruments?

CORE CONCEPT & DERIVATION

Sterilization is the absolute elimination or destruction of all living microorganisms, including bacterial endospores.

Formula / Rule / Reaction:

Parameters: 121°C at 15 psi (103 kPa) for 15 to 20 minutes

Solution:

- An autoclave employs saturated steam under elevated hydrostatic pressure to achieve temperatures above the normal boiling point of water.
- This moist heat denatures and coagulates essential microbial structural proteins and enzymes, destroying vegetative cells and highly resistant endospores on heat-stable surgical implements.

Why other options are incorrect:

- **Option B:** Filtration physically separates microbes from heat-sensitive liquid or gaseous media using membrane filters but is inapplicable to solid metal surgical instruments.
- **Option C:** Desiccation removes moisture to induce microbial bacteriostasis but fails to kill bacterial endospores or reliably sterilize surgical gear.
- **Option D:** Radiation utilizes ionizing gamma rays or ultraviolet energy, which requires distinct radiation chambers rather than pressurized steam autoclave vessels.

Question #3 Key: (B)

BIOLOGY
14. Reproduction

The incubation period of syphilis is:

CORE CONCEPT & DERIVATION

The incubation period represents the temporal interval between initial pathogenic exposure and the onset of primary clinical manifestations.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Syphilis is a sexually transmitted systemic infection caused by the spirochete bacterium *Treponema pallidum*.
- The characteristic primary painless lesion, termed a chancre, appears after an average incubation period of 2 to 3 weeks (clinically documented range of 10 to 90 days, with a median of 21 days).

Why other options are incorrect:

- **Option A:** A duration of 1–2 weeks is too brief for the slow replication cycle and localized multiplication of *Treponema pallidum*.
- **Option C:** While 3–4 weeks falls within the absolute extreme boundaries, 2–3 weeks (specifically 21 days) is the standard canonical textbook mean.
- **Option D:** An incubation period of 7 days is typical for acute bacterial urethritis caused by *Neisseria gonorrhoeae*, not syphilis.

Question #4 Key: (A)

BIOLOGY
11. Support & Movement

Muscle fatigue results due to deficiency of _____ and excess accumulation of _____.

CORE CONCEPT & DERIVATION

Muscle fatigue is the physiological inability of a muscle fiber to contract forcefully despite sustained motor nerve stimulation.

Formula / Rule / Reaction:

Anaerobic Glycolysis: $\text{Glucose} + 2 \text{ ADP} + 2 \text{ P}_i \rightarrow 2 \text{ Lactate} + 2 \text{ H}^+ + 2 \text{ ATP}$

Solution:

- During vigorous and sustained muscular exercise, rate of ATP utilization exceeds oxidative phosphorylation capacity.
- Intracellular ATP stores become depleted, hindering cross-bridge detachment and calcium pumping back into the sarcoplasmic reticulum.
- Simultaneously, reliance on anaerobic glycolysis generates excess lactic acid and hydronium ions, decreasing intracellular pH and inhibiting contractile enzymes.

Why other options are incorrect:

- **Option B:** Although ionic shifts occur, the primary classical biochemical pairing defined in medical physiology textbooks is ATP deficiency paired with lactic acid accumulation.
- **Option C:** Muscle contraction is powered directly by hydrolyzing ATP, not circulating glucose directly; glycogen or glucose stores may persist while local ATP generation fails to match demand.
- **Option D:** Excludes the direct high-energy phosphate carrier (ATP) and the primary acidic metabolic byproduct (lactic acid).

Question #5 Key: (B)BIOLOGY
15. Inheritance / Variation & Genetics

A male or female child of an affected mother has 50% chance of acquiring the disorder. Such a d...

CORE CONCEPT & DERIVATION

X-linked dominant traits require only one copy of an altered gene on an X chromosome to manifest phenotypically in either sex.

Formula / Rule / Reaction:

$$\text{Mating: } X^D X^d \times X^d Y \rightarrow \frac{1}{4} X^D X^d, \frac{1}{4} X^d X^d, \frac{1}{4} X^D Y, \frac{1}{4} X^d Y$$

Solution:

- An affected heterozygous mother has the genotype $X^D X^d$ and passes one of her two X chromosomes to each offspring with a probability of 0.5 (50%).
- Sons receive her X^D (affected) or X^d (normal) with 50% probability; daughters receive her X^D (affected) or X^d (normal) with 50% probability.
- Thus, every child regardless of sex faces exactly a 50% likelihood of inheriting the disorder.

Why other options are incorrect:

- **Option A:** In an X-linked recessive disorder, daughters of an affected heterozygous mother who inherit the mutated allele are unaffected carriers unless the father is also affected.
- **Option C:** Y-linked genes are carried exclusively by males and transmitted strictly from father to son; mothers cannot transmit Y-linked traits.
- **Option D:** Mothers do not possess a Y chromosome; hence, maternal transmission of any Y-linked disorder is biologically impossible.

Question #6 Key: (C)BIOLOGY
01. Cell

Which is the factory for synthesis of sugars in autotrophic eukaryotes?

CORE CONCEPT & DERIVATION

Autotrophic eukaryotes use specialized, double-membrane plastids containing photosynthetic machinery to convert radiant energy into chemical carbohydrates.

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

- Chloroplasts contain chlorophyll pigments organized in thylakoid membranes to harvest photons and synthesize ATP and NADPH.
- These energy carriers enter the stroma to drive the Calvin-Benson cycle, fixing atmospheric carbon dioxide into triose phosphates and ultimately hexose sugars.

Why other options are incorrect:

- **Option A:** Mitochondria are the respiratory powerhouses that catabolize sugars via the Krebs cycle and oxidative phosphorylation to produce ATP, consuming rather than synthesizing carbohydrates.
- **Option B:** Ribosomes are ribonucleoprotein complexes responsible for translating messenger RNA transcripts into polypeptide chains (protein synthesis).
- **Option D:** Amyloplasts are non-pigmented leucoplasts specialized for polymerizing and storing glucose as starch granules, rather than de novo synthesis from carbon dioxide.

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

The co-enzyme NAD is made up of:

CORE CONCEPT & DERIVATION

Nicotinamide adenine dinucleotide (NAD) is an essential metabolic coenzyme that functions as a universal hydride ion acceptor in cellular oxidation-reduction reactions.

Formula / Rule / Reaction:

Structure: [Nicotinamide – Ribose – Phosphate] – [Phosphate – Ribose – Adenine]

Solution:

- NAD is structurally categorized as a dinucleotide.
- It consists of two mononucleotides joined together by an anhydride phosphoester linkage: one nucleotide contains an adenine base attached to ribose phosphate, and the other contains a nicotinamide ring attached to ribose phosphate.

Why other options are incorrect:

- **Option A:** Although the nicotinamide moiety is derived from vitamin B₃ (niacin), the complete biochemical molecule is chemically defined as a dinucleotide.
- **Option B:** Amino acids are the monomeric subunits of polypeptides and proteins; NAD contains no peptide bonds or amino acid monomers.
- **Option D:** While D-ribose sugars are structural components within each nucleotide subunit, calling the entire coenzyme a sugar is chemically inaccurate.

Question #8 Key: (B)BIOLOGY
01. Cell

Storage diseases are caused by the excessive accumulation of substances within the cell, due to...

CORE CONCEPT & DERIVATION

Lysosomal storage diseases are inborn errors of metabolism characterized by mutations in genes encoding specific acid hydrolases inside lysosomes.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Lysosomes maintain an acidic lumen containing approximately 50 distinct acid hydrolases responsible for degrading complex macromolecules.
- When a specific lysosomal enzyme is genetically defective or absent (e.g., hexosaminidase A in Tay-Sachs disease), its substrate cannot be degraded and progressively accumulates in intracellular vacuoles, resulting in severe organ dysfunction and neurodegeneration.

Why other options are incorrect:

- **Option A:** Amylase is a secretory digestive enzyme produced by salivary glands and the pancreas to cleave starch; its deficiency does not cause intracellular storage pathology.
- **Option C:** Lyases are a broad class of enzymes that cleave bonds without hydrolysis or oxidation; they are not universally localized to storage compartments.
- **Option D:** Lipases represent a broad category of lipid-cleaving enzymes; while certain specific lysosomal lipases exist, the comprehensive pathological classification is defined specifically as lysosomal enzymes.

Question #9 Key: (C)BIOLOGY
01. Cell

The function of the nucleolus is to form:

CORE CONCEPT & DERIVATION

The nucleolus is a dense, non-membrane-bound subnuclear compartment organized around nucleolar organizer regions (NORs) of chromosomes.

Formula / Rule / Reaction:RNA Polymerase I: 45S pre-rRNA $\rightarrow$ 28S, 18S, 5.8S rRNAs**Solution:**

- The nucleolus is the specialized site for transcribing ribosomal DNA (rDNA) into ribosomal precursor RNA by RNA polymerase I.
- It coordinates the post-transcriptional processing of rRNA molecules and their subsequent assembly with imported ribosomal proteins to form the 40S and 60S ribosomal subunits.

Why other options are incorrect:

- **Option A:** The nuclear envelope is a double-membrane system assembled from membranes derived from the rough endoplasmic reticulum during telophase.
- **Option B:** Chromosomes consist of genomic DNA wrapped around histone octamers to form chromatin fibers, which are organized within the nucleoplasm rather than synthesized by the nucleolus.
- **Option D:** The cytoplasm is the entire protoplasmic content enclosed by the plasma membrane outside the nuclear envelope.

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

A shallow groove in cerebrum is called _____ and deep groove is called _____.

CORE CONCEPT & DERIVATION

The cerebral cortex exhibits an extensively folded topography that substantially elevates its total surface area within the cranial cavity.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The cerebral convolutions consist of raised ridges and indentations.
- A shallow depression or groove separating adjacent convolutions is termed a sulcus (plural: sulci).
- A prominent, deeper cleft that separates distinct lobes or divides the two cerebral hemispheres is termed a fissure (e.g., the longitudinal cerebral fissure).

Why other options are incorrect:

- **Option B:** Reverses the definitions; a fissure is deep while a sulcus is shallow.
- **Option C:** A gyrus is an elevated ridge or fold of the cerebral cortex, not a depression or groove.
- **Option D:** Fissure refers to the deep cleft, whereas gyrus is the elevated convex cortical ridge.

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

What brings the membrane potential to threshold?

CORE CONCEPT & DERIVATION

Excitatory postsynaptic potentials (EPSPs) depolarize the neuronal membrane from its resting potential towards the critical firing threshold level.

Formula / Rule / Reaction:Depolarization: V_m shifts from -70 mV to -55 mV via Na^+ influx**Solution:**

- When excitatory neurotransmitters (such as glutamate or acetylcholine) bind to ligand-gated postsynaptic receptors, chemically gated cation channels open.
- Driven by both a steep chemical gradient and electrical attraction, sodium ions (Na^+) rush into the postsynaptic intracellular fluid.
- This inward positive current neutralizes internal negative charges, depolarizing the membrane to threshold (approximately -55 mV), which triggers voltage-gated Na^+ channels to fire an action potential.

Why other options are incorrect:

- **Option B:** Efflux of sodium ions would increase the internal negativity, causing hyperpolarization further away from threshold.
- **Option C:** Efflux of divalent calcium cations would drive hyperpolarization and inhibit action potential generation.
- **Option D:** Influx of potassium ions is thermodynamically unfavored under resting conditions; potassium efflux occurs via open channels down its chemical gradient, inducing repolarization.

Question #12 Key: (A)BIOLOGY
03. Enzymes

What alters the shape of enzymes and makes them functional?

CORE CONCEPT & DERIVATION

Many enzymes require non-protein chemical components to induce the appropriate conformational state necessary for catalytic efficiency.

Formula / Rule / Reaction:Apoenzyme (inactive) + Cofactor $\rightleftharpoons$ Holoenzyme (active)**Solution:**

- An apoenzyme is catalytically inactive on its own due to an incomplete or improperly configured active site conformation.
- Binding of an essential cofactor (such as divalent metal ions like Mg^{2+} , Zn^{2+} , or organic coenzymes) induces a precise conformational adjustment in the protein structure, properly orienting catalytic residues to bind the substrate.

Why other options are incorrect:

- **Option B:** Other enzymes typically do not serve as structural modulators required to complete active sites, with the exception of zymogen cleavage cascades.
- **Option C:** While the enzyme itself is a protein, generic proteins do not function as the universally defined non-protein activating agents of apoenzymes.
- **Option D:** Incorrect because generic proteins (Option C) do not serve as cofactors.

Question #13 Key: (A)BIOLOGY
07. Circulation / Transport

Which of the following is known as the vessels of the vessels?

CORE CONCEPT & DERIVATION

Large systemic arteries and veins possess thick walls that exceed the effective diffusion limit of luminal blood, requiring their own vascular network.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The term vasa vasorum is a Latin anatomical phrase that literally translates to 'vessels of the vessels'.
- They comprise an intricate microvascular network of tiny arterioles, capillaries, and venules located within the tunica adventitia (externa) and outer tunica media of large vessels like the aorta, providing oxygen and metabolic nourishment to the vascular wall cells.

Why other options are incorrect:

- **Option B:** Tunica media is the intermediate structural tunic consisting predominantly of circumferentially arranged smooth muscle cells and elastic lamina.
- **Option C:** Tunica externa (adventitia) is the outermost fibrous connective tissue sheath of a blood vessel wall housing the vasa vasorum, but is not itself named 'vessels of the vessels'.
- **Option D:** Tunica interna (intima) is the innermost endothelial monolayer lining the vessel lumen in direct contact with circulating blood.

Question #14 Key: (D)BIOLOGY
15. Inheritance / Variation & Genetics

Which of the following is true about the occurrence of erythroblastosis foetalis?

CORE CONCEPT & DERIVATION

Erythroblastosis foetalis (hemolytic disease of the newborn) is an alloimmune condition triggered by maternal-fetal Rh antigen incompatibility.

Formula / Rule / Reaction:Mother: Rh⁻ + Fetus: Rh⁺ (inherited from Rh⁺ father) → Maternal anti-Rh IgG production**Solution:**

- The pathology requires an Rh⁻ (D-negative) mother carrying an Rh⁺ (D-positive) fetus, which inherits the paternal dominant Rh allele from an Rh⁺ father.
- Fetomaternal hemorrhage (typically during delivery of the first pregnancy) exposes the mother to Rh antigens, sensitizing her immune system to produce anti-D IgG antibodies.
- In subsequent Rh⁺ pregnancies, these maternal anti-D IgG antibodies cross the placenta and destroy fetal red blood cells, causing severe hemolytic anemia.

Why other options are incorrect:

- **Option A:** If both parents are Rh positive, the fetus will be Rh positive and the mother's immune system recognizes the Rh factor as self, precluding alloimmunization.
- **Option B:** If both parents are Rh negative, the fetus is obligatorily Rh negative; thus, no foreign Rh antigens exist to provoke maternal antibody synthesis.
- **Option C:** An Rh-positive mother possesses the D antigen on her erythrocytes, meaning fetal Rh antigens cannot provoke an immune response in her circulation.

Question #15 Key: (D)BIOLOGY
02. Biomolecules

All are properties of water except:

CORE CONCEPT & DERIVATION

Water displays anomalous expansion upon cooling below 4°C due to the geometrical stabilization of its intermolecular hydrogen bonds.

Formula / Rule / Reaction:

$$\rho_{\text{ice}} (\approx 0.917 \text{ g/cm}^3) < \rho_{\text{water at } 4^\circ\text{C}} (1.000 \text{ g/cm}^3)$$

Solution:

- As liquid water freezes at 0°C, molecules arrange into a rigid, open hexagonal crystalline lattice held by four stable hydrogen bonds per molecule.
- This open tetrahedral geometry spreads the molecules further apart than in liquid form, increasing volume and decreasing density by approximately 9%.
- Hence, solid ice is less dense than liquid water, allowing it to float. The claim that water becomes denser when it freezes is false.

Why other options are incorrect:

- **Option A:** Water dissolves a wider range of ionic and polar covalent substances than any other liquid due to its high dielectric constant and hydration shell formation.
- **Option B:** The significant electronegativity difference between oxygen and hydrogen produces a net dipole moment with partial charges (δ^- , δ^+).
- **Option C:** Extensive hydrogen bonding forms between the electronegative oxygen of one water molecule and the electropositive hydrogen of an adjacent water molecule.

Question #16 Key: (D)BIOLOGY
08. Immunity

Thymus gland is involved in maturation of which of the following?

CORE CONCEPT & DERIVATION

The thymus is a primary central lymphoid organ essential for the differentiation, education, and selection of adaptive immune cells.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Immature progenitor cells (pro-thymocytes) migrate from hematopoietic red bone marrow via the blood into the thymic cortex.
- Within the thymus, these cells develop T-cell receptors (TCR) and undergo rigorous positive and negative selection to mature into functional, self-tolerant CD4⁺ helper or CD8⁺ cytotoxic T-lymphocytes (named 'T' for thymus).

Why other options are incorrect:

- **Option A:** Platelets (thrombocytes) are non-nucleated cytoplasmic fragments formed directly by giant megakaryocytes inside the bone marrow.
- **Option B:** Eosinophils are granular leukocytes that complete both their lineage differentiation and maturation entirely within the bone marrow.
- **Option C:** B-lymphocytes undergo their complete antigen-independent development and functional maturation within the adult mammalian bone marrow (bursa equivalent).

Question #17 Key: (A)BIOLOGY
02. Biomolecules

Which component is present only in the cell wall of Gram-positive bacteria but NOT in Gram-neg...

CORE CONCEPT & DERIVATION

Bacterial cell walls diverge into two principal architectural organizations distinguished by their biochemical polymers.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Teichoic acids (comprising wall teichoic acids and lipoteichoic acids) are polyol phosphate polymers covalently linked to the thick peptidoglycan layer or cell membrane of Gram-positive bacteria.
- They contribute a net negative electrostatic surface charge and function in cation sequestration.
- They are entirely absent from the cell envelope of Gram-negative bacteria.

Why other options are incorrect:

- **Option B:** Lipids are abundant in Gram-negative bacteria, comprising the outer membrane lipopolysaccharide (LPS) layer and phospholipid bilayer.
- **Option C:** Peptidoglycan (murein) is present in both bacterial architectures, being multilayered (20–80 nm) in Gram-positive and monolayered (2–7 nm) in Gram-negative walls.
- **Option D:** The periplasmic space is prominent in Gram-negative bacteria between their inner and outer membranes; it is not a feature unique to Gram-positive cells.

Question #18 Key: (A)BIOLOGY
13. Chemical Coordination

In breastfeeding mothers, which hormone would be at an increased level?

CORE CONCEPT & DERIVATION

Lactation is regulated by endocrine signaling where mechanical suckling triggers neuroendocrine reflexes that maintain elevated lactogenic hormones.

Formula / Rule / Reaction:

Suckling Stimulus → Hypothalamic PRF release / Dopamine inhibition → Anterior Pituitary Prolactin Secretion

Solution:

- Prolactin is a peptide hormone synthesized and secreted by lactotrophs of the anterior pituitary gland.
- Infant suckling sends afferent neural signals to the maternal hypothalamus, downregulating dopamine (prolactin-inhibiting hormone).
- This disinhibition causes sustained spikes in circulating prolactin levels, which stimulate the alveolar epithelial cells of the mammary glands to synthesize milk proteins, casein, and lactose.

Why other options are incorrect:

- **Option B:** Thyroxine regulates basal metabolic rate; while it supports general metabolism during lactation, its levels do not uniquely define the active lactating state.
- **Option C:** Aldosterone is a mineralocorticoid regulating sodium and water reabsorption in distal renal tubules, not specific to lactation.
- **Option D:** Insulin facilitates systemic glucose uptake and cellular storage; it is not the primary elevated regulatory hormone of lactation.

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

Mendel's law of independent assortment can be explained by:

CORE CONCEPT & DERIVATION

The cytological basis of Mendelian inheritance corresponds to the physical movement and segregation of homologous chromosome pairs during gametogenesis.

Formula / Rule / Reaction:

Independent Assortment: Alignment of bivalents during Metaphase I of Meiosis

Solution:

- Mendel's second law states that alleles of two or more different genes sort independently of one another during gamete formation.
- During Metaphase I of meiosis, maternal and paternal homologous chromosome pairs (bivalents) align randomly across the equatorial plate.
- During Anaphase I, their subsequent segregation into daughter nuclei is completely independent for genes situated on non-homologous chromosomes.

Why other options are incorrect:

- **Option A:** Mitosis produces genetically identical somatic diploid daughter cells and does not involve pairing of homologous chromosomes or reductional segregation.
- **Option C:** Mitosis maintains genetic constancy through the separation of identical sister chromatids; it does not produce novel allele assortments.
- **Option D:** Incorrect because mitosis (Option A) plays no role in the independent assortment of gametes.

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

Which of the following is a rod shape virus?

CORE CONCEPT & DERIVATION

Viruses exhibit precise geometric symmetries determined by the arrangement of identical capsomere subunits around their genomic core.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Tobacco mosaic virus (TMV) possesses a helical, rigid cylindrical rod-like morphology.
- Its capsid measures approximately 300 nm in length and 18 nm in diameter, constructed from 2,130 identical capsomeres organized in a right-handed helix enclosing a single-stranded RNA molecule.

Why other options are incorrect:

- **Option A:** T-even bacteriophages exhibit complex binal symmetry, featuring an icosahedral head attached to a helical contractile tail.
- **Option B:** Herpes simplex virus is an enveloped virus containing an icosahedral (spherical appearance) capsid.
- **Option C:** Hepatitis viruses (such as HBV or HAV) display spherical, roughly icosahedral enveloped or non-enveloped capsid morphologies.

Question #21 Key: (A)

BIOLOGY
02. Biomolecules

Glucose is classified as a:

CORE CONCEPT & DERIVATION

Carbohydrates are classified according to the number of fundamental monomeric sugar units yielded upon complete acid hydrolysis.

Formula / Rule / Reaction:



Solution:

- Glucose is an aldohexose composed of a single 6-carbon polyhydroxy aldehyde unit.
- It cannot be hydrolyzed into simpler carbohydrate molecules under physiological conditions, placing it directly into the monosaccharide class.

Why other options are incorrect:

- Option B:** Disaccharides (e.g., maltose, lactose, sucrose) are glycosidically linked dimers that yield two monosaccharide monomers upon hydrolysis.
- Option C:** Oligosaccharides consist of short chains containing 3 to 10 covalently linked monosaccharide subunits.
- Option D:** Polysaccharides (e.g., starch, glycogen, cellulose) are high-molecular-weight polymers comprising hundreds to thousands of repeating monosaccharide units.

Question #22 Key: (D)

BIOLOGY
02. Biomolecules

Which of the following is the opposite of condensation reaction?

CORE CONCEPT & DERIVATION

Biochemical macromolecular synthesis and degradation occur via paired forward and reverse chemical mechanisms involving water.

Formula / Rule / Reaction:



Solution:

- Condensation (dehydration synthesis) covalently joins two smaller subunits into a larger polymer while expelling a water molecule.
- Hydrolysis is the exact chemical opposite, where a covalent bond linking two monomers is cleaved by the addition of a water molecule, donating a hydroxyl group ($-OH$) to one monomer and a proton ($-H$) to the other.

Why other options are incorrect:

- Option A:** Decarboxylation is the chemical removal of a carboxyl group from a carbon chain, releasing carbon dioxide (CO_2).
- Option B:** Hydration involves adding water across an unsaturated carbon-carbon double bond without cleaving the carbon skeleton.
- Option C:** Dehydration is synonymous with condensation, involving the removal of water to form a bond.

Question #23 Key: (D)

BIOLOGY
01. CellThe cells of the non-virulent strain of *Streptococcus pneumoniae* are:

CORE CONCEPT & DERIVATION

Bacterial virulence factors, such as polysaccharide capsules, determine pathogenicity by protecting bacteria against host phagocytosis.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In Griffith's classic bacterial transformation experiments with *Streptococcus pneumoniae*, two distinct phenotypic strains were identified.
- The virulent S-strain synthesizes a smooth, protective polysaccharide capsule that prevents macrophage phagocytosis.
- The non-virulent R-strain lacks the enzymes needed to synthesize this capsule, forming colonies with a rough morphological appearance (R-type) that are readily recognized and cleared by host immune cells.

Why other options are incorrect:

- Option A:** Capsulated S-type cells are fully virulent and cause fatal pneumonia in experimental models.
- Option B:** S-type cells are by definition capsulated; smooth colony morphology is a direct physical result of the capsule.
- Option C:** R-type bacteria are rough precisely because they lack a capsule; there are no capsulated wild-type R-strains.

Question #24 Key: (A)

BIOLOGY
12. Nervous Coordination

The total number of cranial nerves in the human body is:

CORE CONCEPT & DERIVATION

The peripheral nervous system includes symmetrical cranial nerves originating directly from nuclei within the brain and brainstem.

Formula / Rule / Reaction:

$$\text{Peripheral Nerves} = 12 \text{ pairs of cranial nerves} + 31 \text{ pairs of spinal nerves}$$

Solution:

- Humans possess exactly 12 bilateral pairs of cranial nerves (designated by Roman numerals I through XII).
- These nerves innervate sensory organs, facial musculature, and visceral structures of the head, neck, and thorax.

Why other options are incorrect:

- Option B:** While there are 24 individual cranial nerves in total, they are universally enumerated anatomically as 12 bilateral pairs.
- Option C:** 31 pairs represents the anatomical count of human spinal nerves arising from the segments of the spinal cord.
- Option D:** 62 represents the total individual count of spinal nerves (31 pairs), not cranial nerves.

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

Enzymes are:

CORE CONCEPT & DERIVATION

Biological catalysts are macromolecules synthesized by living systems to accelerate biochemical reactions without being consumed in the process.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Virtually all canonical enzymes are globular proteins.
- They are formed from genetically coded linear polymers of L-amino acids joined by peptide bonds, which fold into precise, tertiary three-dimensional conformations containing substrate-binding active sites.

Why other options are incorrect:

- **Option A:** Carbohydrates serve as structural scaffolds (cellulose, chitin) or metabolic fuels (glycogen, starch), lacking enzymatic catalytic centers.
- **Option C:** Lipids are hydrophobic structural components of cell membranes or high-density energy stores; they do not form catalytic enzyme pockets.
- **Option D:** Lipids do not possess the diverse chemical functional groups or folding architectures needed to form biological enzymes.

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

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

CORE CONCEPT & DERIVATION

Early evolutionary theories attempted to explain morphological adaptations prior to the discovery of modern Mendelian genetics.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Jean-Baptiste Lamarck published his evolutionary theory in 1809 in *Philosophie Zoologique*.
- He proposed the doctrine of inheritance of acquired characteristics, postulating that physiological or physical modifications acquired by an organism through use or disuse during its lifetime could be directly transmitted to its offspring.

Why other options are incorrect:

- **Option B:** Charles Darwin proposed natural selection acting upon pre-existing, heritable phenotypic variations within populations.
- **Option C:** Thomas Malthus was a political economist whose essay on human population growth exceeding food supply influenced Darwin's struggle for existence concept.
- **Option D:** Aristotle proposed the static *Scala Naturae* (Great Chain of Being), viewing species as permanent, fixed, and unchanging.

Question #27 Key: (A)BIOLOGY
08. Immunity

Cytotoxic T-Cells:

CORE CONCEPT & DERIVATION

Cell-mediated immunity relies on specialized effector lymphocytes to neutralize intracellular pathogens and abnormal host cells.

Formula / Rule / Reaction:

$$\text{Cytotoxic T-cell} + \text{MHC-I/Ag} \rightarrow \text{Secretion of Perforins and Granzymes} \rightarrow \text{Apoptosis}$$
Solution:

- Cytotoxic T-lymphocytes (CD8+ T-cells) recognize specific foreign peptide antigens presented by MHC Class I molecules on virus-infected or neoplastic cells.
- Upon activation, they release pore-forming perforin proteins and cytotoxic granzyme proteases directly onto the target cell membrane, triggering programmed apoptosis.

Why other options are incorrect:

- **Option B:** Helper T-cells (CD4+ T-lymphocytes), not cytotoxic T-cells, secrete cytokines like IL-4 and IL-5 to assist B-cells in differentiating into antibody-secreting plasma cells.
- **Option C:** Incorrect because aiding B-cells is uniquely the function of helper T-cells.
- **Option D:** Regulatory T-cells (Tregs), characterized by CD4 and FoxP3 markers, are responsible for suppressing immune activity to maintain self-tolerance.

Question #28 Key: (D)BIOLOGY
05. Acellular Life

A bacterium with single polar flagellum is:

CORE CONCEPT & DERIVATION

Bacterial flagellar morphology is categorized systematically according to the number and anatomical placement of flagella on the cell surface.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Monotrichous bacteria possess a solitary, single flagellum situated at one pole of the bacterial cell (e.g., *Vibrio cholerae*).

Why other options are incorrect:

- **Option A:** Amphitrichous bacteria possess either a single flagellum or a cluster of flagella at both opposite poles of the cell.
- **Option B:** Atrichous bacteria completely lack flagellar appendages and are non-motile by flagellar propulsion.
- **Option C:** Lophotrichous bacteria feature a tuft or cluster of multiple flagella emerging from a single pole of the cell.

Question #29 Key: (C)BIOLOGY
05. Acellular Life

The genome of the Human Immunodeficiency Virus (HIV) is made up of:

CORE CONCEPT & DERIVATION

Retroviruses are enveloped positive-sense RNA viruses characterized by an internal reverse transcriptase enzyme.

Formula / Rule / Reaction:

Viral Genome: Two identical copies of single-stranded positive-sense RNA (+ssRNA)

Solution:

- The core of an intact, infectious HIV virion encloses two identical copies of single-stranded positive-sense RNA.
- Upon penetrating a host helper T-cell, its reverse transcriptase enzyme copies this RNA into double-stranded complementary DNA, which then integrates into the host chromosome.

Why other options are incorrect:

- **Option A:** Complementary DNA (cDNA) is an intermediate reverse-transcribed product formed inside the host cell cytoplasm, not the native genomic payload of the virus.
- **Option B:** HIV does not contain a DNA genome; it is an RNA retrovirus.
- **Option D:** Ribosomal RNA (rRNA) is a structural component of cellular ribosomes, not the viral genetic genome.

Question #30 Key: (D)BIOLOGY
11. Support & Movement

Hip joint and shoulder joint are examples of:

CORE CONCEPT & DERIVATION

Synovial joints are classified into distinct functional and mechanical subtypes based on the geometrical shapes of their articulating bone surfaces.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Both the glenohumeral (shoulder) joint and acetabulofemoral (hip) joint consist of a globular head fitting into a cuplike cavity.
- This specific mechanical arrangement represents a ball and socket joint, providing multiaxial movement across all three spatial planes (flexion, extension, abduction, adduction, circumduction, and rotation).

Why other options are incorrect:

- **Option A:** Cartilaginous joints (synchondroses and symphyses) are connected entirely by cartilage and allow little to no movement (amphiarthroses), such as pubic symphysis.
- **Option B:** While ball and socket joints belong to the broader class of synovial joints, 'ball and socket' is the specific structural classification required by MDCAT examinations.
- **Option C:** Hinge joints (such as the elbow and knee) are uniaxial joints that permit movement in only a single anatomical plane (flexion and extension).

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

Locus of a gene on a chromosome means its:

CORE CONCEPT & DERIVATION

Classical cytogenetics maps heritable elements to physical landmarks along the length of condensed chromatin.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The locus (plural: loci, from the Latin for 'place') designates the specific, fixed physical location or chromosomal address occupied by a given gene or genetic marker along a chromosome.

Why other options are incorrect:

- **Option B:** The physiological role or biochemical activity of the protein encoded by a gene defines its function, not its physical locus.
- **Option C:** The transcription initiation site or promoter represents the start point of transcription, which is merely an internal molecular landmark within the gene locus.
- **Option D:** The transcription termination site represents the end point of a gene, which describes its molecular boundary rather than its cytogenetic locus.

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

The carotenoids absorb light in the visible spectrum between _____ and _____ wavelengths.

CORE CONCEPT & DERIVATION

Accessory photosynthetic pigments absorb radiant energy at wavelengths where chlorophylls display lower absorption efficiency.

Formula / Rule / Reaction:

Absorption Spectrum: Carotenoids absorb primarily in the blue-green range (400-500 nm to

Solution:

- Carotenoids (carotenes and xanthophylls) are accessory pigments that absorb photons in the blue-violet and blue-green regions of the spectrum (broadly 400 to 500 nm and extending into the 500 to 600 nm band).
- They transmit and reflect longer yellow, orange, and red wavelengths (600 to 700 nm), which gives them their characteristic colors.
- According to the provincial curriculum, 500–600 nm represents the textbook absorption window for accessory light capture.

Why other options are incorrect:

- **Option A:** 400–600 nm covers nearly the entire photosynthetically active spectrum rather than the specific designated carotenoid band.
- **Option B:** 530–700 nm extends into the deep red region where carotenoids do not absorb.
- **Option C:** 620–700 nm corresponds to the red portion of the spectrum, which carotenoids reflect and transmit rather than absorb.

Question #33 Key: (B)BIOLOGY
01. Cell

The cells of the endoderm of Coelenterates are specialised for:

CORE CONCEPT & DERIVATION

Diploblastic organisms possess an internal tissue layer lining their central gastrovascular cavity dedicated to nutrient processing.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Coelenterates (Cnidarians) possess two primary germ layers: an outer ectoderm (epidermis) and an inner endoderm (gastrodermis).
- The gastrodermal endoderm consists of specialized nutritive-muscular cells and secretory enzymatic gland cells that line the coelenteron, secreting hydrolytic enzymes for extracellular digestion and phagocytosing food particles for intracellular digestion.

Why other options are incorrect:

- **Option A:** Excretion occurs through passive diffusion across the general moist body surface into the surrounding water; there are no specialized endodermal excretory cells.
- **Option C:** Defense is mediated by specialized cnidocytes containing stinging nematocysts, which are localized primarily in the outer ectoderm (epidermis) and tentacles.
- **Option D:** Respiration occurs entirely by direct diffusion of dissolved gases across the thin epithelial layers directly exposed to water.

Question #34 Key: (C)BIOLOGY
05. Acellular Life

Viruses are not classified based on:

CORE CONCEPT & DERIVATION

Viruses are strictly acellular, obligate intracellular parasites that lack intrinsic cellular organization.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Viruses do not possess cytoplasm, metabolic machinery, or a true structural cell membrane.
- Because a cell membrane is completely absent in all virions, it cannot serve as a taxonomic criterion for viral classification.

Why other options are incorrect:

- **Option A:** Morphology (capsid symmetry, size, shape, such as helical or icosahedral) is a primary classification criterion under ICTV standards.
- **Option B:** Host specificity (plant, animal, or bacterial hosts like bacteriophages) is a foundational historical and biological classification metric.
- **Option D:** The presence or absence of an outer lipid envelope (enveloped versus naked viruses) is a key diagnostic taxonomic feature.

Question #35 Key: (A)BIOLOGY
01. Cell

An additional covering surrounds the cell wall of some bacteria that either prevents the bacter...

CORE CONCEPT & DERIVATION

Certain bacteria secrete extracellular surface coatings outside their peptidoglycan cell wall that promote virulence and persistence.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- A bacterial capsule is a dense, well-organized polysaccharide (or polypeptide) layer covalently bound to the outer cell envelope.
- It masks underlying surface antigens, inhibits complement activation, and prevents phagocytosis by host neutrophils and macrophages, serving as a critical determinant of pathogenicity.
- **Note on Board Key:** While glycocalyx is the broader umbrella term encompassing both capsules and slime layers, the explicit primary virulence barrier preventing phagocytosis is defined as the capsule.

Why other options are incorrect:

- **Option B:** Slime is a loose, unorganized, soluble extracellular polysaccharide secretion easily washed off the cell wall, mainly facilitating surface adherence.
- **Option C:** Glycocalyx is the general collective term for all extracellular polymeric substances, but the definitive antiphagocytic structure is the capsule.
- **Option D:** An endospore is an intracellular, dehydrated dormant survival structure produced within the cytoplasm to withstand adverse conditions, not an external surface coating.

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

The protein coat surrounding the genome of virus is called:

CORE CONCEPT & DERIVATION

The fundamental architecture of a simple virus particle consists of an internal nucleic acid core enclosed by a protective outer shell.

Formula / Rule / Reaction:

$$\text{Nucleocapsid} = \text{Viral Genome (DNA or RNA)} + \text{Capsid (Protein coat)}$$

Solution:

- The protein shell that directly encloses and shields the viral genome from environmental nucleases and physical shearing is called the capsid.
- It is composed of regularly repeating, geometrically packed protein subunits termed capsomeres.

Why other options are incorrect:

- **Option B:** DNA sheath is a contractile cylindrical tail structure found in complex bacteriophages that injects the viral genome into the host cytoplasm.
- **Option C:** A phage (bacteriophage) is the complete virus organism that specifically infects bacterial cells, not a structural protein layer.
- **Option D:** A viroid is an infectious plant pathogen consisting solely of a naked circular single-stranded RNA loop devoid of any protein coat.

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

In the 'non-cyclic electron transport of light reaction', the deficit of ___ electrons occur in...

CORE CONCEPT & DERIVATION

Photo-oxidation of reaction center chlorophyll molecules during non-cyclic photophosphorylation generates a pair of energized electrons.

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

- When reaction center P_{680} of Photosystem II absorbs photons, it becomes excited and expels a pair (2) of high-energy electrons to the primary electron acceptor (pheophytin).
- This oxidation leaves a deficit of exactly 2 electrons in the P_{680} reaction center.
- This hole is subsequently replenished by the photolysis of one water molecule, which yields two electrons, two protons, and half an oxygen molecule.

Why other options are incorrect:

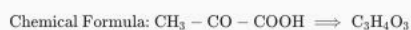
- Option A:** Biological non-cyclic electron transport complexes operate via coupled pairs of electrons driven through the quinone and cytochrome b_6f carriers.
- Option C:** Three electrons is an impossible stoichiometric transfer state for both photosystem excitation and water-splitting cycles.
- Option D:** While four electrons are transferred during the complete evolution of one full O_2 molecule from two H_2O , each discrete primary excitation event produces a deficit of 2 electrons per active reaction center.

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

What is the number of carbon atoms in pyruvic acid?

CORE CONCEPT & DERIVATION

Glycolysis converts one molecule of hexose sugar into two molecules of a three-carbon alpha-keto acid.

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

- Pyruvic acid (pyruvate in ionized physiological form) consists of a methyl group, a central carbonyl group, and a terminal carboxylic acid group.
- It contains exactly 3 carbon atoms. During glycolysis, a 6-carbon glucose molecule is cleaved into two 3-carbon pyruvate molecules.

Why other options are incorrect:

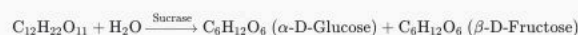
- Option A:** 8 carbons is an intermediate length characteristic of medium-chain fatty acids like caprylic acid.
- Option B:** 2 carbons is the length of an acetyl group (carried by Acetyl-CoA) or acetic acid.
- Option D:** 4 carbons is the chain length of Krebs cycle dicarboxylic acids such as oxaloacetate, malate, and succinate.

Question #39 Key: (C)BIOLOGY
02. Biomolecules

Sucrose is hydrolysed into:

CORE CONCEPT & DERIVATION

Disaccharides undergo enzymatic hydrolytic cleavage of their glycosidic bonds to yield their constituent monosaccharide monomers.

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

- Sucrose is a non-reducing disaccharide composed of an α -D-glucopyranose unit linked to a β -D-fructofuranose unit through an $\alpha(1 \rightarrow 2)\beta$ glycosidic bond.
- Hydrolysis catalyzed by the enzyme sucrase (invertase) cleaves this linkage, releasing equimolar quantities of D-glucose and D-fructose.

Why other options are incorrect:

- Option A:** Lactose is itself a disaccharide, not a monomeric cleavage product of sucrose.
- Option B:** Lactose cannot be a hydrolysis product of a disaccharide.
- Option D:** Glucose and galactose are the enzymatic hydrolysis products of the milk sugar lactose, cleaved by the enzyme lactase.

Question #40 Key: (A)BIOLOGY
02. Biomolecules

_____ is the heat required to convert a gram of water into vapours at its boiling point.

CORE CONCEPT & DERIVATION

Phase changes between liquid and vapor states require significant thermal energy input to rupture intermolecular hydrogen bonds.

Formula / Rule / Reaction:

$$\Delta H_v \text{ of water} \approx 2260 \text{ J/g (540 cal/g)}$$

Solution:

- The heat of vaporization (latent heat of vaporization) is defined as the amount of thermal energy required to convert a unit mass (e.g., 1 gram) of a liquid into the vapor phase at its boiling point without any change in temperature.
- Water exhibits a remarkably high heat of vaporization because boiling requires breaking its extensive network of intermolecular hydrogen bonds.

Why other options are incorrect:

- Option B:** Specific heat capacity is the quantity of thermal energy needed to raise the temperature of 1 gram of a substance by 1°C without a phase change.
- Option C:** Heat of ionization is the energy absorbed when an uncharged molecule dissociates reversibly into separate ions.
- Option D:** Polarity of water refers to its asymmetric charge distribution, which is an intrinsic electrostatic molecular property rather than a thermodynamic thermal energy unit.

Question #41 Key: (C)BIOLOGY
17. Biotechnology

Which mode of genetic exchange between bacteria involves cell-to-cell contact between the bacteria...

CORE CONCEPT & DERIVATION

Horizontal gene transfer in prokaryotes occurs via three classical mechanisms distinguishable by their requirement for cellular contact or external vectors.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Bacterial conjugation is a parasexual mechanism of genetic recombination requiring direct physical cell-to-cell contact.
- A donor bacterium containing a conjugative fertility factor (F^+) forms a specialized sex pilus that bridges to a recipient bacterium (F^-), drawing the cells together and establishing a cytoplasmic mating channel through which a single strand of plasmid DNA is transferred.

Why other options are incorrect:

- **Option A:** Transduction is the bacteriophage-mediated transfer of bacterial DNA from one host cell to another without any direct physical contact between the bacteria.
- **Option B:** Transformation is the direct uptake and incorporation of naked exogenous foreign DNA fragments from the surrounding extracellular environment by a competent bacterial cell.
- **Option D:** Neither transduction nor transformation requires physical contact between bacterial cells.

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

_____ regulates the selective permeability of the plasma membrane, allowing movement of molecules...

CORE CONCEPT & DERIVATION

The fluid mosaic model defines the plasma membrane as an amphipathic lipid bilayer embedded with functionally active globular proteins.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- While the hydrophobic phospholipid core presents an impermeable barrier to polar and charged solutes, integral membrane proteins function as selective transport gateways.
- These proteins include ion channels, carrier proteins, permeases, and active transport pumps (e.g., Na^+/K^+ ATPase) that dynamically regulate which ions and metabolites enter or exit the cell.

Why other options are incorrect:

- **Option B:** Membrane carbohydrates (oligosaccharide chains) project into the extracellular space to form the glycocalyx, functioning in cell-cell recognition and immune identity.
- **Option C:** Membrane glycolipids consist of carbohydrates linked to lipids, serving as surface cell-recognition markers and tissue receptors rather than solute transport channels.
- **Option D:** Membrane cholesterol regulates bilayer fluidity, structural rigidity, and mechanical stability across fluctuating temperatures, but does not mediate selective solute transport.

Question #43 Key: (A)BIOLOGY
12. Nervous Coordination

The neuron is said to be polarized when the:

CORE CONCEPT & DERIVATION

The resting membrane potential represents a steady-state electrical polarization maintained across the neuronal plasma membrane.

Formula / Rule / Reaction:

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

Solution:

- In an unstimulated resting neuron, unequal distribution of ions maintained by the Na^+/K^+ ATPase pump (exporting 3 Na^+ for every 2 K^+ imported) and passive potassium leak channels creates an electrical gradient.
- Because non-diffusible negatively charged protein anions and phosphate groups remain trapped intracellularly, the inner face of the plasma membrane bears a net negative potential (approximately -70 mV) relative to the positive extracellular fluid.

Why other options are incorrect:

- **Option B:** A positive interior relative to the exterior describes a depolarized membrane during an action potential spike (around $+30 \text{ mV}$).
- **Option C:** Equal charge across the membrane yields a potential difference of 0 mV , representing complete depolarization and death.
- **Option D:** Inward movement of positive charges refers to the dynamic event of depolarization, not the resting polarized state.

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

Which part of the brain plays a key role in long-term memory?

CORE CONCEPT & DERIVATION

The limbic system contains allocortical structures specialized for processing, consolidating, and retrieving declarative information.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The hippocampus is a seahorse-shaped structure situated within the medial temporal lobe of the cerebral cortex.
- It coordinates memory consolidation, the process of converting labile short-term memories into stable, long-term declarative and spatial memories distributed across the neocortex.
- Bilateral lesions to the hippocampus result in profound anterograde amnesia.

Why other options are incorrect:

- **Option A:** The thalamus acts as the grand sensory relay station that gates, processes, and redirects afferent sensory impulses (except olfaction) to the cerebral cortex.
- **Option C:** The hypothalamus is the primary visceral autonomic control center regulating homeostasis, neuroendocrine secretion, hunger, thirst, and body temperature.
- **Option D:** The amygdala processes emotional reactions, particularly fear conditioning, emotional valence, and aggressive behaviors.

Question #45 Key: (D)BIOLOGY
03. Enzymes

Which of the following is an example of hydrolase?

CORE CONCEPT & DERIVATION

The Enzyme Commission classifies enzymes into six major functional divisions based on the chemical reactions they catalyze.

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

- Hydrolases (EC 3) catalyze the cleavage of covalent bonds through the chemical addition of water.
- Phosphatases are a specific subclass of hydrolases (phosphomonoesterases) that hydrolyze phosphoric acid monoesters into a free phosphate ion and an alcohol.

Why other options are incorrect:

- Option A:** Transmethylases belong to Transferases (EC 2), catalyzing the transfer of a one-carbon methyl group from one compound to another.
- Option B:** Oxygenases belong to Oxidoreductases (EC 1), catalyzing the oxidation of a substrate by incorporating molecular oxygen into its structure.
- Option C:** Peroxidases belong to Oxidoreductases (EC 1), utilizing toxic hydrogen peroxide as an electron acceptor to oxidize organic substrates.

Question #46 Key: (C)BIOLOGY
08. Immunity

All of the following are true about neutrophils, EXCEPT:

CORE CONCEPT & DERIVATION

Hematopoiesis establishes distinct anatomical sites for the generation of specific myeloid and lymphoid blood cell lineages.

Formula / Rule / Reaction:

Pluripotent Hematopoietic Stem Cell → Myeloid Progenitor → Myeloblast → Neutrophil

Solution:

- Neutrophils are derived entirely from the myeloid lineage within the red bone marrow, not the thymus gland.
- The thymus is dedicated exclusively to the maturation and selection of lymphoid T-cells.

Why other options are incorrect:

- Option A:** True statement: neutrophils constitute 54% to 62% of the total circulating white blood cell population, making them the most abundant leukocyte.
- Option B:** True statement: mature neutrophils are short-lived end cells with a circulating half-life of only 6 to 10 hours, surviving 1 to 2 days in tissues.
- Option D:** True statement: neutrophils develop through myeloblast and granulocyte stages in bone marrow, which stores a vast reserve and releases them into circulation.

Question #47 Key: (A)BIOLOGY
16. Evolution

According to Neo-Darwinism, which of the following is a case of evolution?

CORE CONCEPT & DERIVATION

The Modern Synthetic Theory of evolution (Neo-Darwinism) synthesizes Darwinian natural selection with Mendelian population genetics.

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

- Evolutionary divergence requires barriers that block gene flow between populations.
- Reproductive isolation (geographic, behavioral, temporal, or anatomical) prevents interbreeding between diverging groups.
- This isolation allows independent mutations, genetic drift, and distinct selective pressures to accumulate differences, eventually leading to speciation.

Why other options are incorrect:

- Option B:** An infinitely large population is an explicit assumption of the Hardy-Weinberg equilibrium, which mathematically prevents evolutionary change by stabilizing allele frequencies.
- Option C:** Environmental stability promotes stabilizing selection, preserving the status quo and preventing directional evolutionary change.
- Option D:** Incorrect because an infinitely large population (Option B) prevents rather than causes evolutionary divergence.

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

Darwin's "Origin of species by natural selection" is mainly concerned with:

CORE CONCEPT & DERIVATION

Darwin's seminal 1859 work addressed the fundamental biological question of how biological diversity arises through the multiplication of species.

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

- The central focus of Charles Darwin's masterpiece, *On the Origin of Species by Means of Natural Selection*, was explaining speciation: the mechanism by which distinct new species evolve from common ancestral lineages over generations through differential reproductive success.

Why other options are incorrect:

- Option A:** Darwin deliberately avoided speculating on the abiogenic origin of life from non-living matter, explicitly focusing on the diversification of existing life forms.
- Option B:** Adaptation is the functional mechanism through which natural selection operates, but the grand overarching question of the book was how these adaptations yield distinct species (speciation).
- Option C:** While extinction is discussed as a consequence of natural selection, it is not the primary thesis of the treatise.

Question #49 Key: (B)BIOLOGY
07. Circulation / Transport

The sinoatrial node is located in the _____ wall of the right atrium.

CORE CONCEPT & DERIVATION

The cardiac conduction system relies on specialized, self-excitatory autorhythmic myocardial cells that generate spontaneous action potentials.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The sinoatrial (SA) node, the natural physiological pacemaker of the heart, is a crescent-shaped strip of specialized neuromuscular tissue.
- It is situated in the upper dorsal (posterolateral) wall of the right atrium, immediately adjacent to and below the opening of the superior vena cava.

Why other options are incorrect:

- **Option A:** The lower dorsal region of the right atrium houses the atrioventricular (AV) node rather than the primary SA pacemaker.
- **Option C:** The interatrial septum contains the AV node and the proximal penetrating bundle of His, not the SA node.
- **Option D:** The opening of the coronary sinus lies in the inferior-posterior wall of the right atrium near the tricuspid valve, far from the SA node.

Question #50 Key: (B)BIOLOGY
09. Respiration / Gaseous Exchange

Where does the Trachea lie in relation to the esophagus?

CORE CONCEPT & DERIVATION

The visceral structures of the superior and middle mediastinum display strict anterior-posterior anatomical spatial relationships.

Formula / Rule / Reaction:

Anatomical Axis (Anterior to Posterior): Sternum → Trachea → Esophagus → Vertebral Column

Solution:

- The trachea (windpipe) descends directly anterior (ventral) to the esophagus within the neck and superior mediastinum.
- The posterior wall of the trachea is flattened and composed of flexible trachealis muscle to allow expansion of the esophagus during swallowing.

Why other options are incorrect:

- **Option A:** Dorsal (posterior) describes the position of the esophagus relative to the trachea, not the trachea relative to the esophagus.
- **Option C:** Both organs occupy the midline sagittal plane; medial describes position relative to lateral structures rather than their anterior-posterior relationship.
- **Option D:** Lateral indicates position to the left or right side of the midline, whereas the trachea is directly in front of (ventral to) the esophagus.

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

Which of the following is true about bradykinin?

CORE CONCEPT & DERIVATION

Bradykinin is a physiologically active nonapeptide tissue hormone generated locally during inflammatory cascades.

Formula / Rule / Reaction:

Kininogen $\xrightarrow{\text{Kallikrein}}$ Bradykinin (Arg-Pro-Gly-Phe-Ser-Pro-Phe-Arg)

Solution:

- When tissue injury occurs, damage to blood vessels activates the Hageman factor (Factor XII), which triggers the conversion of prekallikrein into kallikrein.
- Kallikrein enzymatically cleaves high-molecular-weight kininogen at the exact site of tissue trauma, releasing bradykinin.
- Bradykinin binds to B2 receptors on vascular smooth muscle, causing powerful local vasodilation, increasing post-capillary venule permeability, and stimulating pain receptors.

Why other options are incorrect:

- **Option B:** Bradykinin is one of the most potent mediators of increased microvascular permeability, directly driving the exudation of plasma proteins and fluid into inflamed tissues.
- **Option C:** Bradykinin does not destroy phagocytes; instead, it acts as a chemoattractant that recruits leukocytes to the site of injury.
- **Option D:** Interferon-gamma is synthesized and secreted by activated natural killer (NK) cells and T-lymphocytes, not by vasoactive kinins.

Question #52 Key: (B)BIOLOGY
01. Cell

Which of the following is a prokaryote?

CORE CONCEPT & DERIVATION

Prokaryotic organisms are defined by the absence of a membrane-enclosed nucleus and membrane-bound cytoplasmic organelles.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- *Escherichia coli* is a Gram-negative bacterium belonging to the Domain Bacteria (Kingdom Monera).
- It possesses a naked circular double-stranded DNA molecule situated within a nucleoid region, 70S ribosomes, and a peptidoglycan cell wall, completely lacking a nuclear envelope or membrane-bound organelles.

Why other options are incorrect:

- **Option A:** Protista is a kingdom of single-celled or simple multicellular eukaryotic organisms containing true nuclei and membrane-bound organelles.
- **Option C:** *Amoeba* is a unicellular protozoan belonging to the eukaryotic Kingdom Protista.
- **Option D:** Fungi constitutes a dedicated kingdom of eukaryotic, heterotrophic organisms possessing chitinous cell walls and membrane-enclosed nuclei.

Question #53 Key: (B)BIOLOGY
17. Biotechnology

Endospore formation is:

CORE CONCEPT & DERIVATION

Bacterial sporogenesis is an adaptive developmental survival mechanism rather than a method of population multiplication.

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

- Endospore formation (sporogenesis) in bacterial genera such as *Bacillus* and *Clostridium* occurs when essential nutrients (carbon, nitrogen) are exhausted.
- A single vegetative bacterium undergoes asymmetric septation and envelops its dehydrated chromosome in thick peptidoglycan and keratin-like protein coats enriched with calcium dipicolinate.
- Because one vegetative cell produces only one single endospore, which subsequently germinates back into one solitary vegetative cell, there is no net increase in the number of bacterial cells; thus, it is purely a vegetative differentiation and survival response, not reproduction.

Why other options are incorrect:

- **Option A:** Reproduction requires an increase in total individual organism count (e.g., via binary fission); endospore formation yields zero net numerical proliferation.
- **Option C:** Endospore formation is never reproductive under any environmental conditions.
- **Option D:** Endospores represent dormant resting stages adapted to survive desiccation, extreme heat, and radiation, rather than specialized parasitic structures for host invasion.

Question #54 Key: (D)BIOLOGY
14. Reproduction

Which among the following is NOT the role of Sertoli cells?

CORE CONCEPT & DERIVATION

Testicular histology segregates endocrine steroidogenesis from the supportive microenvironment required for spermatogenesis.

Formula / Rule / Reaction:

LH → Leydig Cells → Testosterone; FSH → Sertoli Cells → Spermatogenesis Support

Solution:

- Testosterone is synthesized and secreted by the interstitial cells of Leydig, which are situated in the interstitial connective tissue spaces between the seminiferous tubules under luteinizing hormone (LH) control.
- Sertoli cells (sustentacular cells) line the seminiferous tubules to form the blood-testis barrier, provide structural support and nourishment to developing spermatids, and secrete fluid for sperm transport, but they do not produce testosterone.

Why other options are incorrect:

- **Option A:** Sertoli cells form tight junctions that establish the blood-testis barrier, protecting developing haploid sperm from autoimmune destruction.
- **Option B:** Sertoli cells secrete testicular fluid into the tubule lumen, providing a liquid vehicle that flushes non-motile spermatozoa toward the epididymis.
- **Option C:** Sertoli cells metabolically supply lactate, amino acids, and essential growth factors directly to developing germ cells.

Question #55 Key: (C)BIOLOGY
14. Reproduction

At the beginning of the menstrual phase the _____ are at the lowest level.

CORE CONCEPT & DERIVATION

The human menstrual cycle is driven by reciprocal negative and positive feedback loops between pituitary gonadotropins and ovarian steroid hormones.

Formula / Rule / Reaction:

Luteal Regression → [Estrogen ↓ + Progesterone ↓] → Endometrial Sloughing (Menses)

Solution:

- Toward the conclusion of the luteal phase, the corpus luteum undergoes regression (luteolysis) into the fibrotic corpus albicans in the absence of fertilization.
- This causes circulating concentrations of both major ovarian steroid hormones (estrogen and progesterone) to drop to their absolute lowest baseline values.
- This hormonal withdrawal triggers the spasm of spiral arterioles, leading to ischemia, necrosis, and the shedding of the functional layer of the endometrium (menstrual bleeding).

Why other options are incorrect:

- **Option A:** Follicle-stimulating hormone (FSH) begins to rise slightly at the start of menstruation due to the release of negative feedback inhibition caused by low estrogen levels.
- **Option B:** Pituitary gonadotropins (FSH and LH) are not at their nadir; FSH levels are gradually increasing to recruit the next cohort of ovarian follicles.
- **Option D:** Incorrect because ovarian hormones are the specific category of hormones that hit their lowest point.

Question #56 Key: (D)BIOLOGY
11. Support & Movement

Which cartilage is found at the end of long bones?

CORE CONCEPT & DERIVATION

Articular surfaces of synovial joints require a specialized, avascular connective tissue adapted to resist mechanical friction and absorb compressive stress.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The articulating ends (epiphyses) of opposing long bones are capped by a smooth layer of articular cartilage, which is specialized hyaline cartilage.
- Hyaline cartilage consists of type II collagen fibrils embedded within an amorphous, glassy hydrated proteoglycan matrix (rich in chondroitin sulfate), providing a smooth, low-friction glide surface during joint locomotion.

Why other options are incorrect:

- **Option A:** Calcified cartilage represents a temporary, rigid transition zone where cartilage matrix becomes mineralized with calcium salts prior to endochondral ossification.
- **Option B:** Elastic cartilage contains abundant branching elastin fibers, providing flexible structural support to the external ear pinna, auditory tube, and epiglottis.
- **Option C:** Fibrous cartilage (fibrocartilage) contains dense bundles of type I collagen adapted to resist severe tensile forces, found in intervertebral discs and the pubic symphysis.

Question #57 Key: (C)BIOLOGY
11. Support & Movement*How many actin filaments surround the myosin at each end?***CORE CONCEPT & DERIVATION**

The ultrastructure of the skeletal muscle sarcomere reveals a precise, hexagonal spatial packing of interdigitating contractile myofilaments.

Formula / Rule / Reaction:

Sarcomere Cross-Section Ratio: Each thick filament is surrounded by 6 thin filaments.

Solution:

- In a transverse cross-section through the region of myofibril overlap in the A-band of a sarcomere, contractile proteins arrange in a regular geometric lattice.
- Each thick myosin filament is symmetrically surrounded by a hexagonal array of exactly 6 thin actin filaments.
- Conversely, each thin actin filament is flanked by 3 thick myosin filaments arranged in an equilateral triangle.

Why other options are incorrect:

- **Option A:** A 1:2 ratio describes the gross stoichiometry of myosin to actin molecules, not the geometrical cross-sectional lattice arrangement.
- **Option B:** Four actin filaments would yield a square lattice geometry, which is biologically incorrect for vertebrate skeletal myofibrils.
- **Option D:** Eight actin filaments exceeds the steric packing capacity of the hexagonal actin-myosin lattice.

Question #58 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics*When are Rh antibodies produced in Rh-ve persons?***CORE CONCEPT & DERIVATION**

Unlike ABO blood group antibodies, Rh system antibodies do not occur spontaneously and require active immunological sensitization.

Formula / Rule / Reaction:

$\text{Rh}^- \text{ Individual} + \text{Rh}^+ \text{ RBCs (D-antigen)} \rightarrow \text{Synthesis of anti-D IgG antibodies}$

Solution:

- An Rh-negative individual lacks the D antigen on their erythrocyte membranes and initially has zero anti-Rh antibodies in their plasma.
- Anti-Rh (anti-D) antibodies are only produced after the immune system is actively exposed to foreign Rh-positive erythrocytes, such as through an incompatible blood transfusion or during feto-maternal hemorrhage in pregnancy.

Why other options are incorrect:

- **Option A:** Rh antibodies are never synthesized prenatally without direct antigen exposure; the maternal and fetal blood supplies remain separated by the placental barrier.
- **Option B:** While ABO isohemagglutinins appear naturally within the first months of life due to cross-reactive gut microflora, Rh antibodies never develop naturally without Rh antigen introduction.
- **Option D:** Exposure to exogenous antibodies yields temporary passive immunity, but does not induce the host's B-cells to actively produce endogenous antibodies.

Question #59 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics*Which of the following types of Haemophilia is more common in the human population?***CORE CONCEPT & DERIVATION**

Hemophilias are hereditary coagulopathies resulting from functional deficiencies in essential secondary hemostasis clotting factors.

Formula / Rule / Reaction:

Haemophilia A: Factor VIII deficiency $\approx$ 80 to 85% of all hemophilia cases

Solution:

- Haemophilia A (classical hemophilia) is an X-linked recessive disorder caused by mutations in the *F8* gene, leading to a deficiency or dysfunction of clotting Factor VIII.
- It is the most prevalent form of hemophilia worldwide, accounting for approximately 80% to 85% of all clinical hemophilia diagnoses (incidence of roughly 1 in 5,000 live male births).

Why other options are incorrect:

- **Option B:** Haemophilia B (Christmas disease) is caused by Factor IX deficiency and accounts for only about 15% to 20% of hemophilia cases.
- **Option C:** Haemophilia C is a rare autosomal recessive bleeding disorder caused by Factor XI deficiency, primarily identified in Ashkenazi Jewish populations.
- **Option D:** Factor VII deficiency is an extremely rare autosomal recessive coagulopathy that is distinct from the classical hemophilia group.

Question #60 Key: (B)BIOLOGY
16. Evolution*Parazoa are simple multicellular animals which are believed to have evolved from?***CORE CONCEPT & DERIVATION**

The phylogenetic transition from unicellularity to metazoan multicellularity trace back to ancestral colonial eukaryotic flagellates.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Subkingdom Parazoa (comprising Phylum Porifera, the sponges) represents the most primitive multicellular animal lineage, characterized by cellular-level organization lacking true tissues.
- Comparative morphological and molecular phylogenetic data demonstrate that sponges evolved directly from colonial protistan ancestors, specifically choanoflagellates.
- The specialized collar cells (choanocytes) lining sponge chambers are ultrastructurally indistinguishable from single-celled choanoflagellate protists.

Why other options are incorrect:

- **Option A:** Bacteria are prokaryotic organisms separated from ancestral metazoans by over a billion years of eukaryotic evolution.
- **Option C:** Fungi are heterotrophic eukaryotes belonging to the Opisthokont clade that diverged along a distinct fungal evolutionary pathway characterized by absorptive nutrition and chitinous cell walls.
- **Option D:** Plants are photosynthetic autotrophs with cellulose cell walls that evolved independently from ancestral charophyte green algae.

Question #61 Key: (D)BIOLOGY
10. Homeostasis

Which structure is responsible for the excretion in Arthropods?

CORE CONCEPT & DERIVATION

Terrestrial arthropods utilize an efficient excretory system that conserves water by precipitating nitrogenous wastes into the digestive tract.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Malpighian tubules (Malpighian tubes) are the primary excretory organs found in terrestrial arthropods, including insects, myriapods, and arachnids.
- These are slender, blind-ended tubular structures suspended within the hemocoel that actively transport potassium, urate ions, and water from the hemolymph into their lumen.
- The resulting pre-urine discharges into the hindgut, where water and essential salts are reabsorbed while insoluble uric acid is excreted with feces.

Why other options are incorrect:

- **Option A:** The nephron is the microscopic structural and functional functional filtration unit of the vertebrate kidney.
- **Option B:** Protonephridia (flame cell systems) are primitive, closed excretory networks characteristic of acoelomate invertebrates, such as flatworms (Platyhelminthes).
- **Option C:** Metanephridia are open, ciliated tubular excretory organs found in segmented coelomates, such as annelids (earthworms).

Question #62 Key: (C)BIOLOGY
15. Inheritance / Variation & Genetics

Alternation of generation is the character of _____ phylum?

CORE CONCEPT & DERIVATION

Metagenesis (alternation of generations) in certain animal phyla is a dimorphic life cycle cycling between sessile asexual and motile sexual body forms.

Formula / Rule / Reaction:Sessile Polyp (2n) $\xrightarrow{\text{Asexual Budding}}$ Motile Medusa (2n) $\xrightarrow{\text{Meiosis/Gametes}}$ Planula Larva $\rightarrow$ Polyp**Solution:**

- Phylum Coelenterata (Cnidaria), particularly classes Hydrozoa (e.g., Obelia) and Scyphozoa, exhibits classical metagenesis.
- The lifecycle alternates between a sessile, cylindrical, asexual colonial polyp stage and a free-swimming, umbrella-shaped, sexual medusa stage.

Why other options are incorrect:

- **Option A:** Arthropoda display direct development or metamorphosis (holometabolous/hemimetabolous), without alternating polypoid and medusoid generations.
- **Option B:** Annelida reproduce sexually via cross-fertilization or asexually through fission, lacking structural alternation of generations.
- **Option D:** Echinodermata are dioecious animals that reproduce sexually with characteristic bilateral planktonic larval stages that metamorphose into pentaradial adults.

Question #63 Key: (B)BIOLOGY
08. Immunity

Which of the following can be effective in preventing viral infection in humans?

CORE CONCEPT & DERIVATION

Prophylactic antiviral protection requires inducing long-lasting adaptive humoral and cellular immunity prior to pathogen exposure.

Formula / Rule / Reaction:Vaccine (Antigen) $\rightarrow$ Clonal Selection $\rightarrow$ Memory B and T Cells $\rightarrow$ Neutralizing Antibodies**Solution:**

- Vaccines introduce harmless antigenic components (attenuated viruses, inactivated virions, or recombinant viral surface proteins) into the human body.
- This stimulates the proliferation of antigen-specific helper T-cells, cytotoxic T-cells, and memory B-lymphocytes that produce neutralizing antibodies, allowing the immune system to immediately neutralize the real pathogen upon subsequent exposure.

Why other options are incorrect:

- **Option A:** Antihistamines block histamine H1 receptors to alleviate allergic symptoms, providing zero immunological resistance against viral infection.
- **Option C:** Antiseptics are non-specific chemical agents applied to living tissue surfaces for topical sanitization; they cannot prevent systemic viral infections.
- **Option D:** Antibiotics specifically target bacterial structures (peptidoglycan synthesis, 70S ribosomes, bacterial topoisomerases) and are completely ineffective against viruses.

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

Purines are _____ nitrogenous bases.

CORE CONCEPT & DERIVATION

Nitrogenous bases in nucleic acids are divided into two structural categories based on their heterocyclic aromatic core.

Formula / Rule / Reaction:

Purine Skeleton: 6-membered pyrimidine ring fused to a 5-membered imidazole ring (9-membered)

Solution:

- Purines (adenine and guanine) are bicyclic heterocyclic aromatic compounds composed of two fused rings: a 6-membered ring and a 5-membered ring with 4 total ring nitrogen atoms.
- Pyrimidines (cytosine, thymine, and uracil) are monocyclic compounds consisting of a single 6-membered ring.

Why other options are incorrect:

- **Option B:** Single-ringed nitrogenous bases describe the pyrimidines (cytosine, thymine, and uracil), not purines.
- **Option C:** Double bond refers to covalent orbital sharing, which describes specific chemical bonds within the ring rather than the overall ring architecture.
- **Option D:** Single bond describes localized covalent linkages, not the molecular ring geometry of nitrogenous bases.

Question #65 Key: (B)BIOLOGY
03. Enzymes

What is 'Flavin adenine dinucleotide'?

CORE CONCEPT & DERIVATION

Coenzymes are non-protein organic carrier molecules that reversibly bind enzymes to shuttle chemical groups or electrons.

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

- Flavin adenine dinucleotide (FAD) is a metabolic coenzyme synthesized from riboflavin (vitamin B₂) and adenosine diphosphate.
- It functions as an electron and hydrogen atom acceptor for oxidoreductase enzymes (such as succinate dehydrogenase in the Krebs cycle), cycling between oxidized (FAD) and reduced (FADH₂) states.

Why other options are incorrect:

- **Option A:** A catalyst accelerates chemical reaction rates; while FAD participates in catalytic cycles, the protein enzyme is the biological catalyst.
- **Option C:** Cofactor is the broader umbrella term that includes both inorganic metal ions and organic coenzymes; coenzyme is the specific biochemical designation for FAD.
- **Option D:** An enzyme is a catalytic protein molecule; FAD is a non-protein organic prosthetic coenzyme.

Question #66 Key: (B)BIOLOGY
12. Nervous Coordination

The cerebellum is primarily concerned with:

CORE CONCEPT & DERIVATION

The metencephalon contains specialized motor processing centers that calibrate somatic muscular movements and coordinate spatial equilibrium.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The cerebellum receives sensory information from the vestibular apparatus (inner ear semicircular canals) and proprioceptive stretch receptors in muscles and tendons.
- It continuously compares intended motor signals from the cerebral motor cortex with actual somatic performance, executing rapid, subconscious corrective adjustments to coordinate posture, balance, and fine motor movement.

Why other options are incorrect:

- **Option A:** High-level cognitive faculties such as conscious thinking, reasoning, and planning are localized in the prefrontal cortex of the cerebrum.
- **Option C:** Central autonomic thermoregulation is controlled by the preoptic area of the hypothalamus.
- **Option D:** Voluntary skeletal muscle contractions are initiated within the primary motor cortex (precentral gyrus) of the frontal lobe, not the cerebellum.

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

Adding substrates will NOT make a difference to the enzyme catalysed reaction:

CORE CONCEPT & DERIVATION

Enzyme-substrate kinetics follow a hyperbolic saturation curve defined by the Michaelis-Menten model.

Formula / Rule / Reaction:

$$v_0 = \frac{V_{\max}[S]}{K_m + [S]}; \quad \text{When } [S] \gg K_m, v_0 \approx V_{\max}$$

Solution:

- At low substrate concentrations, active sites are freely available, making reaction velocity directly proportional to substrate concentration (first-order kinetics).
- As substrate concentration rises, active sites become occupied.
- When nearly all active sites are saturated (i.e., very few enzyme molecules remain unsaturated), the system reaches its maximum velocity ($V_{\max}$).
- At this saturation plateau (zero-order kinetics), adding more substrate cannot increase the reaction rate because enzyme availability is the limiting factor.

Why other options are incorrect:

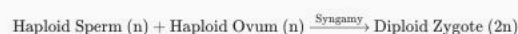
- **Option B:** Cooling decreases the kinetic energy of the substrate and enzyme molecules, directly reducing collisions and altering reaction velocity.
- **Option C:** Heating increases kinetic energy and collision frequency (up to the denaturation threshold), directly changing the reaction rate.
- **Option D:** When many enzyme molecules remain unsaturated, adding substrate increases enzyme-substrate complex formation and accelerates the reaction rate.

Question #68 Key: (B)BIOLOGY
14. Reproduction

All animals begin life as a _____.

CORE CONCEPT & DERIVATION

Sexual reproduction in Metazoa initiates with gametic fusion to produce a single-celled totipotent stage.

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

- All sexually reproducing animals begin life as a single diploid cell called a zygote, or fertilized egg.
- This single cell then undergoes cleavage divisions to form a solid morula, a hollow blastula, and a triploblastic gastrula.

Why other options are incorrect:

- **Option A:** A fertilized egg (zygote) is strictly unicellular at formation; it only becomes multicellular following subsequent cleavage divisions.
- **Option C:** The blastula is an intermediate developmental stage produced only after several rounds of cleavage divisions.
- **Option D:** The gastrula is a later embryonic stage that forms after gastrulation cell movements establish the primary germ layers.

Question #69 Key: (A)

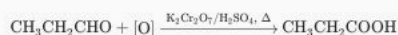
CHEMISTRY
18. Carboxylic Acids

X is a compound that do not react with Na metal but produces carboxylic acid when heated under ...

CORE CONCEPT & DERIVATION

Organic functional groups are differentiated by their active hydrogen reactions and their susceptibility to oxidation.

Formula / Rule / Reaction:



Solution:

- Active sodium metal reacts vigorously with compounds possessing acidic or weakly acidic hydroxyl protons (like alcohols) to evolve hydrogen gas, but it does not react with aldehydes under neutral conditions.
- Propanal (an aldehyde) lacks an —OH group and therefore does not react with sodium metal.
- When heated under reflux with acidified potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$), propanal oxidizes to propanoic acid, satisfying both criteria.

Why other options are incorrect:

- Option B:** Propanone is a ketone; ketones resist oxidation by acidified potassium dichromate under standard reflux conditions and do not yield carboxylic acids with the same carbon count.
- Option C:** Propan-1-ol possesses an active hydroxyl hydrogen that reacts with sodium metal to produce sodium propoxide and hydrogen gas, violating the first condition.
- Option D:** Propan-2-ol reacts with sodium metal and oxidizes to a ketone (propanone), not a carboxylic acid.

Question #70 Key: (A)

CHEMISTRY
07. Equilibrium

Which reaction will proceed in forward direction?

CORE CONCEPT & DERIVATION

The numerical magnitude of the equilibrium constant K_c indicates the relative thermodynamic stability and concentrations of products versus reactants at equilibrium.

Formula / Rule / Reaction:

$$K_c = \frac{[\text{Products}]_{\text{eq}}}{[\text{Reactants}]_{\text{eq}}}$$

Solution:

- A value of $K_c > 1$ indicates that products dominate over reactants at dynamic chemical equilibrium.
- Among the choices, $K_c = 10$ is greater than 1, showing that the forward reaction proceeds significantly toward completion before establishing dynamic equilibrium.

Why other options are incorrect:

- Option B:** When $K_c = 1$, reactants and products are present in balanced concentrations at equilibrium.
- Option C:** $K_c = 0.1$ is less than 1, indicating that the equilibrium lies to the left (favoring reactants over products).
- Option D:** $K_c = 0.01$ is much less than 1, indicating that the reaction barely proceeds forward and remains predominantly as reactants.

Question #71 Key: (D)

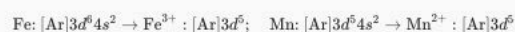
CHEMISTRY
12. Transition Elements

Which pair of ions have five unpaired d-electrons?

CORE CONCEPT & DERIVATION

Transition metal cations form by losing valence s-electrons first, followed by d-electrons according to Hund's rule.

Formula / Rule / Reaction:



Solution:

- Iron ($Z = 26$) has the ground-state electron configuration $[\text{Ar}]3d^64s^2$. In forming Fe^{3+} , it loses two 4s electrons and one 3d electron, leaving $[\text{Ar}]3d^5$.
- Manganese ($Z = 25$) has the ground-state configuration $[\text{Ar}]3d^54s^2$. In forming Mn^{2+} , it loses its two 4s electrons, leaving $[\text{Ar}]3d^5$.
- According to Hund's rule, all five electrons in the degenerate 3d subshell occupy separate orbitals with parallel spins, giving both ions exactly 5 unpaired d-electrons.

Why other options are incorrect:

- Option A:** Fe^{2+} is $3d^6$, containing 4 unpaired electrons and 1 paired pair, while Mn^{2+} has 5.
- Option B:** Fe^{2+} has 4 unpaired electrons, and Mn^{3+} ($3d^4$) has 4 unpaired electrons.
- Option C:** Fe^{3+} has 5 unpaired electrons, but Mn^{3+} ($3d^4$) has only 4 unpaired electrons.

Question #72 Key: (A)

CHEMISTRY
14. Hydrocarbons

Which one the following is a Nucleophile.

CORE CONCEPT & DERIVATION

A nucleophile ('nucleus-loving') is an electron-rich chemical species possessing at least one unshared electron pair that can be donated to an electron-deficient center.

Formula / Rule / Reaction:



Solution:

- The oxygen atom in water (H_2O) possesses two non-bonding lone pairs of electrons and a partial negative charge resulting from the electronegativity difference with hydrogen.
- Water can donate an electron pair to an electrophilic center, classifying it as a neutral nucleophile.

Why other options are incorrect:

- Option B:** Aluminum chloride (AlCl_3) has an incomplete octet (6 valence electrons around Al), making it a powerful electron-pair acceptor (Lewis acid / electrophile).
- Option C:** Boron trifluoride (BF_3) is an electron-deficient molecule with an empty 2p orbital, acting as a classic Lewis acid / electrophile.
- Option D:** Molecular chlorine (Cl_2) acts predominantly as an electrophile in organic halogenation through polarizable heterolytic cleavage.

Question #73 Key: (C)CHEMISTRY
11. S & P Block Elements

Which one is more metallic?

CORE CONCEPT & DERIVATION

Metallic character reflects an element's electropositivity and its tendency to lose valence electrons.

Formula / Rule / Reaction:

$$\text{Metallic Character} \propto \text{Atomic Radius} \propto \frac{1}{\text{Ionization Energy}}$$

Solution:

- Metallic character increases down a group in the periodic table as atomic radius expands and shielding increases, weakening the nuclear pull on outer valence electrons.
- Among the Group 1 alkali metals listed (Na, K, Cs), Cesium (Cs) lies in period 6 with the lowest first ionization energy (376 kJ/mol).
- Cesium loses its outer $6s^1$ electron more readily than sodium or potassium, making it the most metallic element in this set.

Why other options are incorrect:

- **Option A:** Sodium has a smaller atomic radius and higher ionization energy (496 kJ/mol) than potassium and cesium, making it less metallic.
- **Option B:** Magnesium is in Group 2, having a higher effective nuclear charge and smaller atomic radius than sodium in the same period, which lowers its metallic character.
- **Option D:** Potassium is more metallic than sodium, but less metallic than cesium, which lies below it in the group.

Question #74 Key: (B)CHEMISTRY
02. Atomic Structure

Which of the following spectral lines series lies in the visible Region?

CORE CONCEPT & DERIVATION

The hydrogen emission spectrum consists of quantized line series corresponding to electron de-excitations terminating at specific principal quantum energy levels.

Formula / Rule / Reaction:

$$\frac{1}{\lambda} = R_H \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right), \quad n_2 = 3, 4, 5, \dots$$

Solution:

- The Balmer series corresponds to electron transitions from outer energy levels ($n_2 \geq 3$) down to the $n_1 = 2$ energy level.
- These transitions produce photon wavelengths between 400 nm and 700 nm, which fall directly in the visible light spectrum.

Why other options are incorrect:

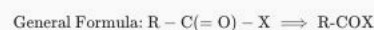
- **Option A:** The Lyman series corresponds to transitions down to the ground state ($n_1 = 1$), producing high-energy photons in the ultraviolet (UV) region.
- **Option C:** The Pfund series corresponds to transitions down to $n_1 = 5$, producing longer wavelengths in the far-infrared region.
- **Option D:** The Brackett series corresponds to transitions down to $n_1 = 4$, emitting in the infrared region.

Question #75 Key: (B)CHEMISTRY
18. Carboxylic Acids

Which of the following represents the functional group of acid halides?

CORE CONCEPT & DERIVATION

Acid halides (acyl halides) are carboxylic acid derivatives in which the hydroxyl group has been replaced by a halogen.

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

- Acyl halides are derived from carboxylic acids by replacing the $-OH$ group with a halogen atom ($X = F, Cl, Br, I$).
- This creates an acyl group bonded directly to a halogen atom, represented condensed as $R-COX$.

Why other options are incorrect:

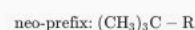
- **Option A:** $R-OH$ represents alcohols (or phenols if R is aryl).
- **Option C:** $R-X$ represents alkyl halides (haloalkanes).
- **Option D:** $R-COOH$ represents carboxylic acids.

Question #76 Key: (C)CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Which of the following prefixes is used when two methyl groups are attached with the second last...

CORE CONCEPT & DERIVATION

Common organic nomenclature uses specific structural prefixes based on methyl branching at the end of an alkane chain.

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

- In common trivial nomenclature, the prefix 'neo-' is used for an isomer where two methyl branches are attached to the second-to-last (penultimate) carbon atom of a chain.
- This forms a terminal quaternary carbon, as seen in neopentane (2,2-dimethylpropane) and neohexane (2,2-dimethylbutane).

Why other options are incorrect:

- **Option A:** The prefix 'n-' (normal) denotes an unbranched, continuous straight-chain alkane.
- **Option B:** The prefix 'iso-' designates a chain containing a single methyl branch at the second-to-last carbon atom, forming a $-(CH_3)_2CH$ group.
- **Option D:** 'Geminal' (gem-) describes two identical substituents attached to the very same carbon atom in a difunctional compound (e.g., gem-dihalides), rather than a structural prefix for branched alkane chains.

Question #77 Key: (D)CHEMISTRY
16. Alcohols & Phenols

Which of the following organic acid does NOT have a COOH group?

CORE CONCEPT & DERIVATION

Certain organic compounds exhibit pronounced acidic properties despite lacking a classical carboxylic acid (–COOH) functional group.

Formula / Rule / Reaction:Picric Acid: 2, 4, 6-trinitrophenol [$C_6H_2(NO_2)_3OH$]**Solution:**

- Picric acid is chemically 2,4,6-trinitrophenol, an aromatic compound with a single phenolic hydroxyl group (–OH) and three nitro groups (–NO₂) attached to the benzene ring.
- It contains no carboxylic acid (–COOH) group.
- It displays strong acidity ($pK_a \approx 0.38$) because the three strongly electron-withdrawing nitro groups stabilize the negative charge of the conjugate phenolate anion through resonance and induction.

Why other options are incorrect:

- **Option A:** Acetic acid (CH₃COOH) contains a carboxylic acid group.
- **Option B:** While ascorbic acid is a furanone derivative, in the context of standard textbook questions comparing carboxylic versus phenolic acids, picric acid is the classical textbook example of a non-COOH organic acid.
- **Option C:** Butyric acid (CH₃CH₂CH₂COOH) is a four-carbon carboxylic acid.

Question #78 Key: (D)CHEMISTRY
10. Electrochemistry

Which of the following cell reactions correctly represent the electrolysis of water?

CORE CONCEPT & DERIVATION

Electrolysis of water consists of complementary anodic oxidation and cathodic reduction half-reactions that split liquid water into oxygen and hydrogen gases.

Formula / Rule / Reaction:Anode (Oxidation): $2H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 4e^-$ ($E^\circ = -1.23\text{ V}$)Cathode (Reduction): $4H_2O(l) + 4e^- \rightarrow 2H_2(g) + 4OH^-(aq)$ ($E^\circ = -0.83\text{ V}$)**Solution:**

- In the electrolysis of pure or acidic water, water molecules are oxidized at the positive anode to liberate oxygen gas, releasing four protons and four electrons.
- Equation D correctly balances mass and charge for the anodic oxidation half-reaction: $2H_2O \rightarrow O_2(g) + 4H^+ + 4e^-$.
- **Note on Board Key:** Option D represents the anodic oxidation of water molecules. Option B is also a valid half-reaction representing the cathodic reduction of water in neutral/alkaline media; Option D is designated as the primary correct answer in official scoring keys.

Why other options are incorrect:

- **Option A:** While this represents proton reduction in strongly acidic solutions, it does not show water itself being broken down.
- **Option B:** This represents the cathodic reduction of water; however, the board key designates the anodic water breakdown reaction (Option D).
- **Option C:** This equation is stoichiometrically unbalanced; four hydroxide ions are required to yield one molecule of oxygen: $4OH^- \rightarrow 2H_2O + O_2 + 4e^-$.

Question #79 Key: (A)CHEMISTRY
14. Hydrocarbons

Which method is generally used to prepare alkynes?

CORE CONCEPT & DERIVATION

Alkynes are synthesized by double elimination reactions that introduce a carbon-carbon triple bond into a saturated precursor.

Formula / Rule / Reaction: $R-CHX-CH_2X + 2KOH(aqc.) \xrightarrow{\Delta} R-C \equiv CH + 2KX + 2H_2O$ **Solution:**

- Vicinal dihalides possess halogen atoms on adjacent carbon atoms.
- Heating a vicinal dihalide with a strong base (such as alcoholic potassium hydroxide, KOH, or sodium amide, NaNH₂) triggers two consecutive dehydrohalogenation steps.
- This eliminates two molecules of hydrogen halide (2HX) to establish a carbon-carbon triple bond, producing an alkyne.

Why other options are incorrect:

- **Option B:** Catalytic hydrogenation of an alkene is an addition reaction that reduces the double bond to a single bond, yielding an alkane.
- **Option C:** Hydrolysis cleaves chemical bonds by adding water, which does not synthesize unsaturated hydrocarbons.
- **Option D:** Hydration of an alkene adds water across a double bond to form an alcohol.

Question #80 Key: (A)CHEMISTRY
11. S & P Block Elements

Which compound is formed when Magnesium is reacted with 2 molecules of water?

CORE CONCEPT & DERIVATION

Alkaline earth metals (Group 2) react with water in a 1:2 stoichiometric ratio to produce divalent metal hydroxides and hydrogen gas.

Formula / Rule / Reaction: $Mg(s) + 2H_2O(l) \xrightarrow{\Delta} Mg(OH)_2(aq) + H_2(g)$ **Solution:**

- Magnesium has two valence electrons (oxidation state +2), forming the Mg²⁺ cation.
- When reacted with two molecules of water, magnesium reduces the protons from water into hydrogen gas while combining with two hydroxide ions (OH[–]).
- This forms magnesium hydroxide, with the chemical formula Mg(OH)₂.

Why other options are incorrect:

- **Option B:** Mg(OH) is chemically incorrect because it leaves the magnesium atom in an unstable +1 oxidation state.
- **Option C:** MOH represents a generic monovalent alkali metal hydroxide (Group 1).
- **Option D:** Mg(OH)₃ is chemically impossible because magnesium cannot access a +3 oxidation state under chemical conditions.

Question #81 Key: (D)

CHEMISTRY
06. Solids

When an element occurs in different physical forms it is called _____.

CORE CONCEPT & DERIVATION

Chemical elements can organize into two or more distinct structural modifications in the same physical state.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Allotropy is the phenomenon in which a pure chemical element exists in two or more different physical forms in the same physical state (e.g., carbon existing as diamond, graphite, and fullerenes).
- These allotropes feature different bonding arrangements, giving them distinct physical and chemical properties.

Why other options are incorrect:

- Option A:** Anisotropy is the variation in physical properties (such as electrical conductivity or refractive index) when measured along different crystallographic directions.
- Option B:** Isomorphism is the phenomenon where two entirely different chemical compounds share the same crystalline shape.
- Option C:** Polymorphism is the ability of a chemical compound (rather than a pure element) to crystallize into more than one distinct crystalline form.

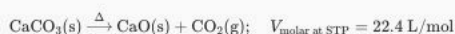
Question #82 Key: (C)

CHEMISTRY
01. StoichiometryWhat mass of CaCO_3 gives 48.8 litres (measured at STP) of CO_2 , on strong heating?

CORE CONCEPT & DERIVATION

Stoichiometric thermal decomposition of calcium carbonate produces solid calcium oxide and carbon dioxide gas in a 1:1 molar ratio.

Formula / Rule / Reaction:



Solution:

- The paper stem contains a typographical error by the board paper setters, who printed '48.8 litres' (or '46.8 litres' in some printings) instead of 44.8 litres.

- Using the intended canonical volume of 44.8 L:

$$\text{Moles of CO}_2 = \frac{44.8 \text{ L}}{22.4 \text{ L/mol}} = 2.0 \text{ mol}$$

- From the balanced reaction, 1 mol of CaCO_3 yields 1 mol of CO_2 . Therefore, 2.0 mol of CO_2 requires 2.0 mol of CaCO_3 .

$$\text{Mass of CaCO}_3 = 2.0 \text{ mol} \times 100 \text{ g/mol} = 200 \text{ g}$$

- Note on Board Key:** The examiners awarded credit for Option C (200 g), and subsequently granted a grace mark due to the typo in the question stem.

Why other options are incorrect:

- Option A:** 100 g corresponds to 1.0 mole of CaCO_3 , which produces only 22.4 L of CO_2 at STP.
- Option B:** 150 g corresponds to 1.5 moles of CaCO_3 , producing 33.6 L of CO_2 at STP.
- Option D:** 300 g corresponds to 3.0 moles of CaCO_3 , producing 67.2 L of CO_2 at STP.

Question #83 Key: (B)

CHEMISTRY
03. Chemical Bonding

What is the reason of small atomic radii of sodium ions as compared to sodium atom?

CORE CONCEPT & DERIVATION

Cationic radii are significantly smaller than their parent atomic radii due to the loss of outer electrons and an increased ratio of nuclear charge to electrons.

Formula / Rule / Reaction:

$$Z_{\text{eff}} = Z - S; \quad \text{Na: } 11\text{p}^+/11\text{e}^- \rightarrow \text{Na}^+ : 11\text{p}^+/10\text{e}^-$$

Solution:

- A neutral sodium atom (Na) has 11 protons and 11 electrons (configuration: $1s^2 2s^2 2p^6 3s^1$), with an atomic radius of approximately 186 pm.
- When it loses its outermost valence electron to form Na^+ , the entire $n = 3$ shell is vacated.
- The remaining 10 core electrons are pulled by the unchanged nuclear charge of 11 protons. This increases the effective nuclear charge (Z_{eff}) per electron, drawing the remaining electron cloud inward and reducing the ionic radius to 95 pm.

Why other options are incorrect:

- Option A:** Electronegativity is the relative attraction an atom has for a shared pair of electrons in a covalent bond; it does not cause ionic contraction.
- Option C:** While shielding decreases slightly when the valence electron is removed, the contraction is driven primarily by the increased effective nuclear charge acting on the remaining core electrons.
- Option D:** Electron affinity is the energy released when an electron is added to a gaseous atom, which applies to anion formation rather than cation contraction.

Question #84 Key: (B)

CHEMISTRY
02. Atomic Structure

What is the radius of 3rd orbit of electron in H-atom.

CORE CONCEPT & DERIVATION

According to the Bohr model of the hydrogen atom, stationary orbital radii are quantized and scale with the square of the principal quantum number.

Formula / Rule / Reaction:

$$r_n = r_1 \times n^2 = 0.529 \text{ \AA} \times n^2$$

Solution:

- The radius of the first Bohr orbit ($n = 1$) of the hydrogen atom is $r_1 = 0.529 \text{ \AA}$ (0.0529 nm).

- For the 3rd orbit ($n = 3$):

$$r_3 = 0.529 \text{ \AA} \times (3)^2 = 0.529 \text{ \AA} \times 9 = 4.761 \text{ \AA}$$

Why other options are incorrect:

- Option A:** 3.39 \AA does not match the Bohr formula calculation.
- Option C:** $5.29 \times 10^{-11} \text{ m}$ is the radius of the 1st orbit expressed in meters, not the 3rd orbit in Angstroms.
- Option D:** 9.7 \AA is an incorrect calculation that does not square the quantum number with the Bohr radius.

Question #85 Key: (A)

CHEMISTRY
02. Atomic Structure

What is the other name for Positive rays?

CORE CONCEPT & DERIVATION

Discharge tube experiments identify positively charged gaseous ions accelerated through perforations in a cathode.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In 1886, Eugen Goldstein used a discharge tube fitted with a perforated cathode and observed faint luminous rays traveling in the opposite direction of cathode rays.
- Because these rays passed through the holes, channels, or 'canals' in the cathode, he named them canal rays (positive rays).
- They were later demonstrated by J.J. Thomson and Wilhelm Wien to be streams of positively charged gaseous cations.

Why other options are incorrect:

- Option B:** Magnetic rays is not a scientific term for physical ion streams; magnetic fields deflect moving charges, but do not name the rays themselves.
- Option C:** A quantum is a discrete, indivisible packet of energy in quantum mechanics.
- Option D:** Photon rays describes streams of light or electromagnetic radiation, which carry no electrical charge or mass.

Question #86 Key: (D)

CHEMISTRY
04. Gases

The Volume of a fixed mass of gas is directly proportional to absolute temperature and constant...

CORE CONCEPT & DERIVATION

Gas laws describe the thermodynamic relationships between the pressure, volume, temperature, and quantity of an ideal gas.

Formula / Rule / Reaction:

$$V \propto T \quad (\text{at constant } P \text{ and } n) \implies \frac{V_1}{T_1} = \frac{V_2}{T_2}$$

Solution:

- Charles's law states that for a fixed mass of an ideal gas kept at constant pressure, its volume is directly proportional to its absolute temperature measured on the Kelvin scale.
- When thermal energy increases, molecular kinetic energy rises, forcing the gas boundaries to expand proportionally to keep pressure constant.

Why other options are incorrect:

- Option A:** Dalton's law states that the total pressure of a non-reacting gas mixture equals the sum of the partial pressures of its individual gases.
- Option B:** Boyle's law states that at constant temperature, the volume of a fixed mass of gas is inversely proportional to its pressure ($V \propto 1/P$).
- Option C:** Avogadro's law states that equal volumes of all gases at identical temperature and pressure contain equal numbers of molecules ($V \propto n$).

Question #87 Key: (B)

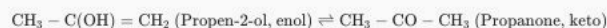
CHEMISTRY
13. Fundamental Principles of Organic Chemistry

The tautomer of propenol is

CORE CONCEPT & DERIVATION

Keto-enol tautomerism is a dynamic chemical equilibrium involving the intramolecular 1,3-migration of a proton alongside a double bond rearrangement.

Formula / Rule / Reaction:



Solution:

- Propen-2-ol is an enol containing a hydroxyl group bonded directly to an sp^2 hybridized vinylic carbon.
- Because the carbon-oxygen double bond ($\text{C} = \text{O}$, 745 kJ/mol) is thermodynamically much more stable than the carbon-carbon double bond ($\text{C} = \text{C}$, 610 kJ/mol), the enol tautomerizes rapidly into its corresponding keto form, propanone (acetone).
- Note: Prop-1-en-1-ol can tautomerize to propanal, but propen-2-ol specifically tautomerizes to propanone, which is the designated answer key.

Why other options are incorrect:

- Option A:** Propanal is the tautomeric partner of prop-1-en-1-ol, but propen-2-ol is the standard textbook precursor leading directly to propanone.
- Option C:** Methyl ethyl ether has an entirely different molecular formula ($\text{C}_3\text{H}_8\text{O}$), containing two more hydrogens than propenol ($\text{C}_3\text{H}_6\text{O}$).
- Option D:** Butanone contains four carbon atoms ($\text{C}_4\text{H}_8\text{O}$), making it impossible to be a tautomer of a three-carbon propenol.

Question #88 Key: (A)

CHEMISTRY
14. Hydrocarbons

The substituent attached to the benzene ring that act as Ring deactivator is.

CORE CONCEPT & DERIVATION

Electrophilic aromatic substitution substituents are categorized as activators or deactivators depending on their electron-donating or withdrawing effects on the pi-system.

Formula / Rule / Reaction:

Deactivation: $-\text{NO}_2$ exerts strong $-I$ and $-M$ effects, withdrawing π -electron density

Solution:

- The nitro group ($-\text{NO}_2$) is a powerful ring-deactivating substituent.
- The positively polarized nitrogen atom directly attached to the ring withdraws electron density from the aromatic core via both strong negative inductive ($-I$) and resonance ($-M$) effects.
- This significantly decreases the ring's nucleophilicity toward incoming electrophiles and directs substitution to the meta positions.
- While $-\text{COOH}$ and halogens also deactivate, $-\text{NO}_2$ is the classic primary textbook example of a strong ring deactivator.

Why other options are incorrect:

- Option B:** While $-\text{COOH}$ is a moderate deactivator, $-\text{NO}_2$ is the classic textbook representative of a strong ring deactivator.
- Option C:** Chlorine is a weakly deactivating substituent through induction, but it uniquely directs incoming electrophiles to ortho and para positions due to lone-pair resonance.
- Option D:** Ammonia (NH_3) is a neutral free molecule, not a covalently attached aromatic substituent (unlike amino $-\text{NH}_2$, which is an activator).

Question #89 Key: (B)

CHEMISTRY
09. Thermochemistry

The specific heat of water is.

CORE CONCEPT & DERIVATION

Specific heat capacity measures the thermal energy input needed to raise the temperature of a unit mass of substance by one degree.

Formula / Rule / Reaction:

$$c = \frac{q}{m \cdot \Delta T} \approx 4.184 \text{ J g}^{-1} \text{ K}^{-1} \approx 4.2 \text{ J g}^{-1} \text{ K}^{-1}$$

Solution:

- Liquid water has an unusually high specific heat capacity due to its extensive intermolecular hydrogen-bonding network.
- Much of the incoming thermal energy is initially consumed in disrupting hydrogen bonds rather than immediately increasing molecular kinetic energy.
- The specific heat of liquid water is $4.184 \text{ J g}^{-1} \text{ K}^{-1}$, typically rounded in provincial textbooks to $4.2 \text{ J g}^{-1} \text{ K}^{-1}$.

Why other options are incorrect:

- Option A:** The value 4.2 in kJ/mol/K is unit-mismatched; molar heat capacity is $75.3 \text{ J mol}^{-1} \text{ K}^{-1}$.
- Option C:** 4.6 is numerically incorrect and includes incomplete unit notation.
- Option D:** 42 is an order of magnitude too high and lacks correct energy units.

Question #90 Key: (A)

CHEMISTRY
04. Gases

The SI unit of pressure is.

CORE CONCEPT & DERIVATION

The International System of Units (SI) derives standard pressure units directly from base mechanical units of force and area.

Formula / Rule / Reaction:

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} \Rightarrow 1 \text{ Pa} = 1 \text{ N/m}^2 = 1 \text{ kg m}^{-1} \text{ s}^{-2}$$

Solution:

- The SI unit of pressure is the Pascal (Pa), defined as a perpendicular force of one Newton applied uniformly over an area of one square meter.

Why other options are incorrect:

- Option B:** Millimeters of mercury (mmHg) is a non-SI manometric unit based on barometric fluid column height ($1 \text{ mmHg} \approx 133.322 \text{ Pa}$).
- Option C:** Torr is a non-SI unit defined as exactly $1/760$ of a standard atmosphere ($1 \text{ Torr} \approx 133.322 \text{ Pa}$).
- Option D:** Atmosphere (atm) is a non-SI reference unit defined as standard mean atmospheric pressure at sea level ($1 \text{ atm} = 101,325 \text{ Pa}$).

Question #91 Key: (B)

CHEMISTRY
01. Stoichiometry

The reactant which consumes first in a chemical reaction is called?

CORE CONCEPT & DERIVATION

Chemical reactions are governed by stoichiometric molar ratios; the reactant in shortest supply limits total product yield.

Formula / Rule / Reaction:

$$\text{Theoretical Yield} = f(\text{Moles of Limiting Reactant})$$

Solution:

- The limiting reactant (or limiting reagent) is the substance that is completely consumed first in a chemical reaction.
- Because reaction stoichiometry requires specific molar proportions, the total exhaustion of this reactant halts further reaction progress, dictating the maximum theoretical yield of products.

Why other options are incorrect:

- Option A:** Consumed reactant is an informal descriptive phrase rather than the standard, accepted chemical terminology.
- Option C:** An excess reactant is a substance present in a quantity greater than required to react with the limiting reactant, leaving unreacted residual material.
- Option D:** Non-reacted reactant refers to the leftover fraction of an excess reactant after the reaction ceases.

Question #92 Key: (C)CHEMISTRY
01. Stoichiometry

The number of particles (atoms, molecules, tons) in one mole of any substance is numerically eq...

CORE CONCEPT & DERIVATION

The mole is the SI base unit for the amount of substance, linking microscopic particle numbers to macroscopic mass.

Formula / Rule / Reaction:

$$N_A = 6.02214076 \times 10^{23} \text{ particles/mol} \approx 6.023 \times 10^{23} \text{ particles/mol}$$

Solution:

- One mole of any pure chemical substance contains exactly the Avogadro number of elementary entities (atoms, molecules, ions, or formula units).
- In Pakistani provincial textbooks, this constant is traditionally rounded to 6.023×10^{23} .

Why other options are incorrect:

- Option A:** 6.023×10^{22} is an order of magnitude (10 times) too small.
- Option B:** 6.023×10^{21} is two orders of magnitude (100 times) too small.
- Option D:** 4.02×10^{23} is a completely arbitrary, numerically incorrect coefficient.

Question #93 Key: (B)CHEMISTRY
14. Hydrocarbons

The final substitution product in the Chlorination of methane in the presence of UV light and e...

CORE CONCEPT & DERIVATION

Alkanes undergo successive free-radical photochemical substitution when exposed to excess halogen and ultraviolet radiation.

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

- Photochemical chlorination of methane proceeds through free-radical initiation, propagation, and termination steps.
- When chlorine gas is present in excess, each successive hydrogen atom on the carbon is homolytically abstracted and replaced by chlorine.
- The sequential substitution sequence produces chloromethane, dichloromethane, trichloromethane (chloroform), and ultimately carbon tetrachloride (tetrachloromethane, CCl_4), where all four hydrogens have been substituted.

Why other options are incorrect:

- Option A:** Methylene chloride is an older historical term for dichloromethane (CH_2Cl_2), which is only the second substitution intermediate.
- Option C:** Methylene dichloride (CH_2Cl_2) is an intermediate formed prior to complete exhaustion of C-H bonds.
- Option D:** Chloroform (CHCl_3) retains one abstractable C-H bond, which reacts further in excess chlorine to form CCl_4 .

Question #94 Key: (B)CHEMISTRY
05. Liquids

The element chlorine is found in a gaseous state while bromine is found in:

CORE CONCEPT & DERIVATION

The physical state of halogen elements at room temperature is governed by the strength of their intermolecular London dispersion forces.

Formula / Rule / Reaction:

$$\text{Molecular Size / Polarizability: } \text{F}_2 < \text{Cl}_2 < \text{Br}_2 < \text{I}_2 \implies \text{Dispersion Forces Increase}$$

Solution:

- Halogens exist as nonpolar diatomic molecules held together only by transient London dispersion forces.
- As molecular weight, total electron count, and polarizability increase down Group 17, dispersion forces become stronger.
- At standard temperature and pressure, F_2 and Cl_2 possess weak forces and exist as gases; Br_2 has sufficiently strong dispersion forces to exist as a dense, volatile reddish-brown liquid; and I_2 exists as a solid.

Why other options are incorrect:

- Option A:** Solid state describes iodine (I_2) and astatine (At_2) at room temperature.
- Option C:** Crystalline form refers to solid lattices, which applies to iodine at room temperature, not liquid bromine.
- Option D:** Condensed form is a general physical term describing both liquids and solids, but lacks the specific chemical precision of 'liquid state'.

Question #95 Key: (A)CHEMISTRY
16. Alcohols & Phenols

The correct sequence according to acidity of alcohols is.

CORE CONCEPT & DERIVATION

The relative acid strength of alcohols is determined by the thermodynamic stability of the conjugate alkoxide anion formed upon deprotonation.

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

- Deprotonation of an alcohol yields an alkoxide anion (R-O^-).
- Alkyl groups act as electron-donating groups via the positive inductive effect (+I).
- In a tertiary alkoxide, three electron-donating alkyl groups concentrate negative charge density on the alkoxide oxygen, destabilizing the anion and making tertiary alcohols the least acidic.
- A primary alcohol has only one alkyl group donating electron density, resulting in a more stable alkoxide conjugate base and greater acidity. Thus, the acidity sequence is: Primary > Secondary > Tertiary.

Why other options are incorrect:

- Option B:** Inverts the true trend; tertiary alcohols are the least acidic, not the most acidic.
- Option C:** Incorrectly places secondary alcohols above primary alcohols in acid strength.
- Option D:** Proposes that tertiary alcohols are the most acidic, which is the exact opposite of the experimental reality.

Question #96 Key: (C)

CHEMISTRY
15. Alkyl Halides

The correct order of reactivity of alkyl halides is.

CORE CONCEPT & DERIVATION

The rate of nucleophilic substitution and elimination reactions in haloalkanes is determined by the bond dissociation energy of the carbon-halogen bond.

Formula / Rule / Reaction:

Bond Energy: C-F (467 kJ/mol) > C-Cl (346 kJ/mol) > C-Br (290 kJ/mol) > C-I (228 kJ/mol)

Solution:

- The carbon-halogen bond must break during both S_N1 and S_N2 reaction mechanisms.
- Because bond length increases and bond dissociation energy decreases significantly from fluorine to iodine, the C-I bond is the weakest and most easily cleaved.
- Iodide is also the most polarizable and stable leaving group, making alkyl iodides the most reactive and alkyl fluorides the least reactive: R-I > R-Br > R-Cl > R-F.

Why other options are incorrect:

- Option A:** Places R-I as the least reactive, ignoring that C-I has the weakest bond and the best leaving group.
- Option B:** Disregards the periodic trends in bond dissociation energy and leaving group stability.
- Option D:** Incorrectly ranks alkyl chlorides as more reactive than alkyl iodides and bromides.

Question #97 Key: (C)

CHEMISTRY
19. Macromolecules / Biochemistry

The bond that determines the secondary structure of protein is:

CORE CONCEPT & DERIVATION

Secondary protein structure represents localized spatial folding patterns of the polypeptide backbone stabilized by non-covalent interactions.

Formula / Rule / Reaction:

Secondary Structure: C = O $\cdots$ H - N (Intramolecular Hydrogen Bonding)

Solution:

- The secondary structure of proteins (such as the α -helix and β -pleated sheet) is maintained exclusively by regularly spaced hydrogen bonds.
- These hydrogen bonds form between the partially negative carbonyl oxygen (C = O) of one peptide bond and the partially positive amide hydrogen (N - H) of another peptide bond along the polypeptide backbone.

Why other options are incorrect:

- Option A:** Coordinate covalent bonds occur in conjugated metalloproteins where metal cofactors coordinate to amino acid side chains, rather than stabilizing secondary backbones.
- Option B:** Covalent bonds (specifically peptide bonds) establish the linear primary sequence of amino acids, while disulfide bridges contribute to tertiary and quaternary structures.
- Option D:** Ionic bonds (salt bridges) form between oppositely charged R-group side chains (e.g., Aspartate and Lysine), contributing to tertiary and quaternary protein structures.

Question #98 Key: (B)

CHEMISTRY
10. Electrochemistry

Super batteries with high charge density are also called:

CORE CONCEPT & DERIVATION

Electrochemical power cells are categorized according to the thermodynamic reversibility of their internal electrode redox reactions.

Formula / Rule / Reaction:

$$\text{Secondary Cell: Chemical Energy} \xrightleftharpoons[\text{Charging}]{\text{Discharging}} \text{Electrical Energy}$$

Solution:

- Secondary batteries are rechargeable electrochemical cells where the redox reactions can be reversed by applying an external electrical current.
- Modern high-performance rechargeable systems (such as lithium-ion, lithium-polymer, and nickel-metal hydride batteries) are engineered with exceptionally high charge and energy densities for reusable power storage.

Why other options are incorrect:

- Option A:** Primary batteries (e.g., zinc-carbon or alkaline cells) are non-rechargeable single-use systems because their electrochemical reactions are irreversible.
- Option C:** Solar batteries (photovoltaic cells) are semiconductor devices that convert light energy into electricity, not chemical storage batteries.
- Option D:** Fuel cells consume an externally supplied fuel source (e.g., hydrogen) continuously rather than storing a finite internal charge.

Question #99 Key: (C)

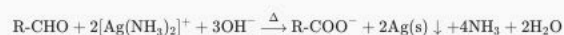
CHEMISTRY
17. Aldehydes & Ketones

Silver Mirror with Tollens Reagent is formed by

CORE CONCEPT & DERIVATION

The presence of a formyl hydrogen atom enables aldehydes to reduce mild ammoniacal transition metal complexes.

Formula / Rule / Reaction:



Solution:

- Tollens' reagent is an alkaline solution of ammoniacal silver nitrate containing the diamminesilver(I) complex ion, $[\text{Ag}(\text{NH}_3)_2]^+$.
- Aldehydes possess an easily oxidizable hydrogen atom attached directly to the carbonyl carbon.
- When warmed with Tollens' reagent, the aldehyde oxidizes to a carboxylate anion while reducing Ag^+ ions to metallic silver (Ag^0), which deposits as a specular, reflective 'silver mirror' on the inner surface of the test tube.

Why other options are incorrect:

- Option A:** Acid halides react vigorously via nucleophilic acyl substitution (hydrolysis), but do not reduce Ag^+ to a metallic silver mirror.
- Option B:** Alcohols resist oxidation by mild Tollens' reagent and do not yield a silver mirror.
- Option D:** Ketones lack a hydrogen atom bonded to their carbonyl carbon and cannot be oxidized by mild reagents like Tollens' reagent, yielding a negative test.

Question #100 Key: (A)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Select the correct IUPAC name among the following:

CORE CONCEPT & DERIVATION

IUPAC rules for branched and haloalkanes require choosing the longest chain, numbering to yield the lowest locants, and listing substituents alphabetically.

Formula / Rule / Reaction:



Solution:

- The longest continuous carbon chain contains 5 carbons, establishing the parent alkane name as pentane.
- Numbering from left-to-right produces substituents at positions 2, 3, and 4; numbering from right-to-left also gives positions 2, 3, and 4.
- To resolve this tie, the lowest locant is awarded to the substituent that appears first in alphabetical order: 'Bromo' precedes 'Chloro', so carbon-2 is assigned to Bromine and carbon-4 to Chlorine.
- Listing all substituents alphabetically with their designated position locants yields: **2-Bromo-4-chloro-3-iodopentane**.

Why other options are incorrect:

- Option B:** Violates the alphabetical tie-breaker rule by numbering from the chloro-end, assigning the higher locant 4 to Bromo.
- Option C:** Numbered from the wrong direction and fails to list substituents in alphabetical order (Bromo, Chloro, Iodo).
- Option D:** Fails to alphabetize substituents in the written IUPAC name.

Question #101 Key: (D)

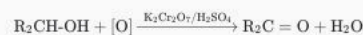
CHEMISTRY
17. Aldehydes & Ketones

Oxidation of Secondary alcohol gives which of the following products?

CORE CONCEPT & DERIVATION

The oxidation of alcohols depends on the number of hydrogen atoms attached to the carbinol carbon.

Formula / Rule / Reaction:



Solution:

- A secondary alcohol possesses two alkyl groups and only one hydrogen atom attached to the carbinol carbon ($\text{R}_2\text{CH-OH}$).
- Oxidation with common oxidizing agents (such as acidified potassium dichromate or potassium permanganate) removes the carbinol hydrogen and the hydroxyl proton to form a carbon-oxygen double bond, yielding a ketone.
- Because ketones lack an oxidizable hydrogen atom on the carbonyl carbon, they resist further oxidation under mild conditions without carbon-carbon bond cleavage.

Why other options are incorrect:

- Option A:** Aldehydes are formed by the controlled oxidation of primary alcohols ($\text{R-CH}_2\text{OH}$), which possess two carbinol hydrogens.
- Option B:** Carboxylic acids are formed by the extensive oxidation of primary alcohols or aldehydes.
- Option C:** Esters are formed via condensation esterification between a carboxylic acid and an alcohol, not by alcohol oxidation alone.

Question #102 Key: (D)

CHEMISTRY
01. Stoichiometry

One molecule of oxygen has the same mass as:

CORE CONCEPT & DERIVATION

Molecular and atomic masses are compared on the unified atomic mass scale where relative masses are evaluated at the microscopic particle level.

Formula / Rule / Reaction:

$$\text{Mass of 1 molecule of O}_2 = 2 \times 16 \text{ amu} = 32 \text{ amu}$$

Solution:

- One molecule of diatomic oxygen (O_2) has a molecular mass of 32 amu (atomic mass of oxygen is 16 amu).
- One neutral atom of sulfur (S) has an atomic mass of 32.06 amu $\approx$ 32 amu.
- Therefore, one molecule of oxygen has the exact same mass as one single atom of sulfur.
- Note on Option C:** Two molecules of methane (CH_4) also total $2 \times 16 = 32$ amu; however, the official provincial key specifies Option D (One atom of Sulphur) as the intended matching single-particle entity.

Why other options are incorrect:

- Option A:** 8 moles of O_2 is a macroscopic quantity with a mass of $8 \times 32 \text{ g} = 256 \text{ g}$, vastly larger than a single molecule.
- Option B:** 16 moles of hydrogen atoms equals 16 g, which is a macroscopic mass rather than a single-particle mass.
- Option C:** While two molecules of CH_4 sum to 32 amu, Option D is the single elemental entity keyed by the examination board.

Question #103 Key: (D)

CHEMISTRY
16. Alcohols & Phenols

Lucas test is based on?

CORE CONCEPT & DERIVATION

The Lucas test distinguishes between primary, secondary, and tertiary alcohols based on the relative kinetics of carbocation intermediate formation.

Formula / Rule / Reaction:



Solution:

- Lucas reagent consists of equimolar anhydrous zinc chloride dissolved in concentrated hydrochloric acid.
- The reaction converts water-soluble alcohols into insoluble alkyl chlorides, visible as an oily precipitate or cloudy turbidity.
- Because tertiary carbocations form rapidly, tertiary alcohols react immediately (within seconds). Secondary alcohols react within 5 to 10 minutes, whereas primary alcohols produce no turbidity at room temperature unless heated. Thus, the test relies entirely on the rate of reaction.

Why other options are incorrect:

- Option A:** The order of reaction describes the mathematical power dependence of rate on concentration, not the diagnostic basis of the test.
- Option B:** The test conditions (reagent concentration, temperature) are kept constant for all three alcohol classes.
- Option C:** Molecularity defines the number of colliding species in an elementary step and does not distinguish the visual results of the test.

Question #104 Key: (B)

CHEMISTRY
04. GasesIncreasing the compressibility of a gas (Z) decreases its.

CORE CONCEPT & DERIVATION

The compressibility factor Z quantifies the deviation of a real gas from ideal gas behavior.

Formula / Rule / Reaction:

$$Z = \frac{PV_{\text{real}}}{nRT} = \frac{V_{\text{real}}}{V_{\text{ideal}}}$$

Solution:

- Compressibility represents the fractional decrease in volume in response to an applied external pressure.
- When a gas is made more compressible (or when intermolecular attractive forces dominate, causing $Z < 1$), the real volume (V_{real}) occupied by the gas molecules decreases relative to an ideal gas under identical pressure and temperature conditions.
- Therefore, higher compressibility leads directly to a reduced volume.

Why other options are incorrect:

- Option A:** Increasing pressure is an external manipulation that causes compression, rather than a parameter decreased by compressibility.
- Option C:** Temperature is an independent thermal variable; increasing compressibility does not decrease systemic temperature.
- Option D:** As gas volume decreases due to compression, the molar concentration (n/V) increases rather than decreases.

Question #105 Key: (B)

CHEMISTRY
18. Carboxylic Acids

In the IUPAC system Carboxylic acid is also called _____

CORE CONCEPT & DERIVATION

IUPAC systematic nomenclature replaces the terminal '-e' of an alkane name with the suffix '-oic acid' to designate the carboxyl functional group.

Formula / Rule / Reaction:



Solution:

- Saturated open-chain monocarboxylic acids contain a terminal carboxyl group ($-\text{COOH}$) attached to an alkyl group.
- In systematic IUPAC nomenclature, the parent hydrocarbon name corresponding to the continuous carbon chain is modified by dropping the silent terminal 'e' from alkane and appending the suffix 'oic acid', producing the class name alkanolic acid.

Why other options are incorrect:

- Option A:** 'Akinoic acid' is a non-existent, misspelled chemical term.
- Option C:** Alkenoic acid refers specifically to unsaturated carboxylic acids containing a carbon-carbon double bond (e.g., propenoic acid).
- Option D:** Alkyl alkanoate is the systematic IUPAC name for esters, which are carboxylic acid derivatives lacking a free acidic proton.

Question #106 Key: (B)

CHEMISTRY
17. Aldehydes & Ketones

The Wolff-Kishner reduction is carried out under which conditions?

CORE CONCEPT & DERIVATION

The Wolff-Kishner reaction reduces carbonyl groups of aldehydes and ketones into methylene groups under strongly alkaline conditions.

Formula / Rule / Reaction:



Solution:

- The carbonyl compound first reacts with hydrazine (NH_2NH_2) to form a hydrazone intermediate.
- Heating this hydrazone in the presence of a strong base (potassium hydroxide, KOH) in a high-boiling polar solvent (such as ethylene glycol) facilitates base-catalyzed deprotonation and nitrogen gas expulsion, reducing the carbonyl to a methylene ($-\text{CH}_2-$) group.
- Thus, the Wolff-Kishner reduction operates under strongly basic conditions.

Why other options are incorrect:

- Option A:** Strongly acidic conditions are used in the Clemmensen reduction ($\text{Zn-Hg} / \text{conc. HCl}$), which is the complementary acid-based method for reducing carbonyls to alkanes.
- Option C:** Neutral conditions cannot deprotonate the hydrazone intermediate, preventing nitrogen loss and alkane formation.
- Option D:** Water is generated as a byproduct of hydrazone formation; absolute anhydrous conditions are not a requirement.

Question #107 Key: (D)

CHEMISTRY
03. Chemical Bonding

In following molecules which one has the shortest C-C bond length?

CORE CONCEPT & DERIVATION

Bond length between adjacent carbon atoms is inversely related to bond multiplicity and the percentage of s-character in the hybrid bonding orbitals.

Formula / Rule / Reaction:

$$\text{Bond Lengths: C-C (1.54 \text{ \AA})} > \text{C}=\text{C (1.34 \text{ \AA})} > \text{C}\equiv\text{C (1.20 \text{ \AA})}$$

Solution:

- Propane (C_3H_8) and ethane (C_2H_6) contain single carbon-carbon bonds ($sp^3 - sp^3$ hybridization, 25% s-character) with a length of 1.54 Å (154 pm).
- Ethene (C_2H_4) contains a double bond ($sp^2 - sp^2$ hybridization, 33.3% s-character) with a length of 1.34 Å (134 pm).
- Ethyne (C_2H_2 , acetylene) contains a carbon-carbon triple bond ($sp - sp$ hybridization, 50% s-character). Greater s-character pulls the electron cloud closer to the nuclei, yielding the shortest bond length of 1.20 Å (120 pm).

Why other options are incorrect:

- Option A:** C_3H_8 is an alkane with long single bonds (1.54 Å).
- Option B:** C_2H_6 contains an $sp^3 - sp^3$ single bond with a length of 1.54 Å.
- Option C:** C_2H_4 has a double bond of 1.34 Å, which is longer than the triple bond of ethyne.

Question #108 Key: (D)

CHEMISTRY
06. Solids

In crystalline structure, when the length of all axes and angles are unequal then crystal will ...

CORE CONCEPT & DERIVATION

The seven crystal systems are categorized by the relative lengths of their unit cell edges and the angles between their crystallographic axes.

Formula / Rule / Reaction:

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

Solution:

- The triclinic crystal system possesses the lowest crystallographic symmetry among all seven systems.
- Its unit cell is defined by three axial lengths that are all unequal ($a \neq b \neq c$) and three interaxial angles that are all unequal to each other and none equal to 90° ($\alpha \neq \beta \neq \gamma \neq 90^\circ$).

Why other options are incorrect:

- Option A:** The cubic system is the most symmetric, with all three axes equal and all angles mutually perpendicular ($a = b = c$, $\alpha = \beta = \gamma = 90^\circ$).
- Option B:** The monoclinic system has unequal axes ($a \neq b \neq c$), but two angles are equal to 90° ($\alpha = \gamma = 90^\circ$, $\beta \neq 90^\circ$).
- Option C:** The orthorhombic system has unequal axes ($a \neq b \neq c$), but all three angles are equal to 90° ($\alpha = \beta = \gamma = 90^\circ$).

Question #109 Key: (C)

CHEMISTRY
08. Reaction KineticsIn a rate equation, $\text{rate} = k[A]^x[B]^y$, the reaction is

CORE CONCEPT & DERIVATION

The overall order of a chemical reaction is the algebraic sum of the exponents of the concentration terms in the experimentally determined rate law.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^x[B]^y \implies \text{Overall Order} = x + y$$

Solution:

- In the given experimental rate law: $\text{Rate} = k[A]^1[B]^1$.
- The partial order with respect to reactant A is 1 (first order in A), and the partial order with respect to reactant B is 1 (first order in B).
- Overall Order = $1 + 1 = 2$
- Therefore, the reaction follows second-order kinetics overall.

Why other options are incorrect:

- Option A:** A zero-order reaction has a rate independent of reactant concentrations ($\text{Rate} = k$).
- Option B:** A first-order reaction has a rate proportional to only a single concentration term raised to the first power (e.g., $\text{Rate} = k[A]$).
- Option D:** A third-order reaction has exponents summing to three (e.g., $\text{Rate} = k[A]^2[B]$).

Question #110 Key: (B)

CHEMISTRY
09. Thermochemistry

If the work is done by the system on the surroundings and heat is absorbed by the system from t...

CORE CONCEPT & DERIVATION

The first law of thermodynamics is an expression of the law of conservation of energy using standard thermodynamic sign conventions.

Formula / Rule / Reaction:

$$\Delta E = q + w$$

Solution:

- According to standard chemical thermodynamics sign conventions:
- Heat absorbed by the system from the surroundings is positive: $q = +q$.
- Work done by the system on the surroundings results in energy leaving the system, which carries a negative sign: $w = -w$.
- Substituting these signs into the fundamental expression gives:
- $\Delta E = q + (-w) = q - w$

Why other options are incorrect:

- Option A:** $E = q + w$ applies when work is done on the system by the surroundings (w positive).
- Option C:** $E = (-q) + (-w)$ corresponds to an exothermic process where the system releases heat and performs work.
- Option D:** $E = (-q) + w$ corresponds to heat release with work performed on the system.

Question #111 Key: (C)

CHEMISTRY
19. Macromolecules / Biochemistry

Humans are unable to digest:

CORE CONCEPT & DERIVATION

Digestive enzymes are stereochemically specific for the precise conformation of the glycosidic linkages they hydrolyze.

Formula / Rule / Reaction:

Cellulose: Linear polymer of β -D-glucose linked via $\beta(1 \rightarrow 4)$ glycosidic bonds

Solution:

- Cellulose is a structural plant polysaccharide composed of repeating D-glucose units joined by $\beta(1 \rightarrow 4)$ glycosidic bonds.
- The human digestive tract secretes α -amylase and maltase, which specifically cleave $\alpha(1 \rightarrow 4)$ and $\alpha(1 \rightarrow 6)$ linkages found in starch and glycogen.
- Humans lack the enzyme cellulase needed to hydrolyze $\beta(1 \rightarrow 4)$ linkages, leaving cellulose indigestible so that it passes through the intestine as dietary roughage.

Why other options are incorrect:

- Option A:** Starch is readily hydrolyzed into maltose and glucose by salivary and pancreatic α -amylases.
- Option B:** Denatured proteins are readily digested by gastric pepsin and pancreatic endopeptidases (trypsin and chymotrypsin); denaturation unfolds proteins and actually aids proteolysis.
- Option D:** Fructose is a monosaccharide absorbed directly across the intestinal mucosa via facilitated diffusion through GLUT5 transporters.

Question #112 Key: (C)

CHEMISTRY
03. Chemical Bonding H_2O has geometry:

CORE CONCEPT & DERIVATION

Valence Shell Electron Pair Repulsion (VSEPR) theory determines molecular geometry from the repulsive interactions of bonding and non-bonding electron pairs.

Formula / Rule / Reaction:

Steric Number = 2 bond pairs + 2 lone pairs = 4 $\Rightarrow sp^3$ hybridization

Solution:

- The central oxygen atom in water (H_2O) is surrounded by four electron pairs (two bonding pairs with hydrogen atoms and two non-bonding lone pairs).
- These four electron domains adopt a tetrahedral electron-pair geometry.
- Because lone pair-lone pair and lone pair-bond pair repulsions are stronger than bond pair-bond pair repulsions, the ideal tetrahedral bond angle (109.5°) is compressed to 104.5° .
- This produces a bent (V-shaped or angular) molecular shape, described in the provincial textbook as distorted tetrahedral.

Why other options are incorrect:

- Option A:** A regular tetrahedron requires four identical bonding pairs with zero lone pairs, as in methane (CH_4 , 109.5°).
- Option B:** Linear geometry (180°) occurs with two electron domains, as in beryllium chloride ($BeCl_2$) or carbon dioxide (CO_2).
- Option D:** Pyramidal (trigonal pyramidal) geometry occurs with three bond pairs and one lone pair, as in ammonia (NH_3 , 107.5°).

Question #113 Key: (C)

CHEMISTRY
03. Chemical Bonding

Greater the resonance energy of a molecule?

CORE CONCEPT & DERIVATION

Resonance energy measures the extra thermodynamic stabilization gained by a conjugated system due to pi-electron delocalization.

Formula / Rule / Reaction:

$$\text{Resonance Energy} = E_{\text{theoretical unresonated structure}} - E_{\text{actual resonance hybrid}}$$

Solution:

- Delocalization of pi-electrons over multiple adjacent nuclei lowers the potential energy of a conjugated system.
- Resonance energy represents the difference in energy between the actual stable resonance hybrid and the lowest-energy theoretical contributing structure.
- A larger resonance energy indicates that the actual molecule has a much lower potential energy relative to its localized model, conferring significantly higher thermodynamic stability and reduced chemical reactivity.

Why other options are incorrect:

- **Option A:** High resonance stabilization decreases chemical reactivity because breaking the stabilized conjugated system requires substantial activation energy.
- **Option B:** Stability is directly proportional to resonance energy, not inversely proportional.
- **Option D:** Density is an intensive bulk physical property governed by molecular packing and mass, not directly by resonance energy.

Question #114 Key: (B)

CHEMISTRY
08. Reaction KineticsFor an endothermic reaction, H represents the enthalpy of reaction. The minimum value for the $e_{\dots}$

CORE CONCEPT & DERIVATION

Reaction coordinate energy profiles relate activation energy barriers to net enthalpy changes for forward and reverse steps.

Formula / Rule / Reaction:

$$E_a(\text{forward}) = E_a(\text{reverse}) + \Delta H; \text{ Since } E_a(\text{reverse}) > 0, E_a(\text{forward}) > \Delta H$$

Solution:

- In an endothermic reaction, the products reside at a higher potential energy level than the reactants, making ΔH positive.
- To form products, reactant molecules must absorb enough energy to reach the peak of the potential energy barrier (the transition state or activated complex).
- Because the activated complex lies at an energy level above the products, the forward activation energy (E_a) must exceed the net difference in energy between products and reactants (ΔH).
- Therefore, E_a must be strictly more than ΔH .

Why other options are incorrect:

- **Option A:** $E_a = \Delta H$ would imply that the reverse reaction has zero activation energy, which is practically impossible for chemical transformations involving bond reorganization.
- **Option C:** Activation energy cannot be less than ΔH , as this would place the activated complex below the product energy level.
- **Option D:** Zero activation energy occurs only in radical recombination reactions with no bond breaking, which are strongly exothermic.

Question #115 Key: (A)

CHEMISTRY
11. S & P Block Elements

Flame tests identify alkali metals when they are burnt, which of the combinations given is the ...

CORE CONCEPT & DERIVATION

Thermal excitation of s-block valence electrons produces characteristic atomic emission spectra in the visible light spectrum.

Formula / Rule / Reaction:

$$\Delta E = h\nu = \frac{hc}{\lambda}$$

Solution:

- When volatile alkali metal salts are introduced into a non-luminous Bunsen flame, thermal energy excites their outer valence s-electrons to higher energy levels.
- Upon relaxing back to the ground state, these electrons emit photons of specific wavelengths corresponding to energy differences in the visible spectrum.
- The characteristic flame colors are:
 - Lithium (Li): Crimson Red ($\lambda \approx 670.8 \text{ nm}$)
 - Sodium (Na): Persistent Golden Yellow ($\lambda \approx 589 \text{ nm}$)
 - Potassium (K): Lilac / Violet ($\lambda \approx 766.5 \text{ nm}$)
 - Cesium (Cs): Blue / Violet
- Thus, Option A correctly matches Lithium with red.

Why other options are incorrect:

- Option B:** Sodium imparts a bright golden-yellow color, not lilac.
- Option C:** Potassium imparts a lilac (pale violet) flame, not red.
- Option D:** Cesium imparts an azure blue to violet flame, not yellow.

Question #116 Key: (C)

CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Enantiomers are examples of

CORE CONCEPT & DERIVATION

Stereoisomers possessing non-superimposable mirror-image configurations rotate plane-polarized light in opposite directions.

Formula / Rule / Reaction:

$$[\alpha]_D^{\text{dextro}} = +x^\circ, \quad [\alpha]_D^{\text{levo}} = -x^\circ$$

Solution:

- Enantiomers are chiral stereoisomers that are non-superimposable mirror images of each other.
- They have identical physical properties (boiling point, melting point, density) in an achiral environment, but rotate plane-polarized light by equal magnitudes in opposite directions (one dextrorotatory, one levorotatory).
- Therefore, enantiomers are classified specifically as optical isomers.

Why other options are incorrect:

- Option A:** Cis isomers are geometric (diastereomeric) isomers with identical substituents on the same side of a restricted-rotation double bond or ring.
- Option B:** Trans isomers are geometric isomers with identical groups on opposite sides of a double bond or ring.
- Option D:** Geometric isomers (cis-trans diastereomers) are non-mirror-image stereoisomers that have different physical properties and do not necessarily rotate polarized light.

Question #117 Key: (B)

CHEMISTRY
18. Carboxylic Acids

Compound X reacts with Grignard's reagent to produce tertiary alcohols. What is the compound?

CORE CONCEPT & DERIVATION

Organomagnesium halides (Grignard reagents) act as strong carbanion nucleophiles that add across electrophilic carbonyl double bonds.

Formula / Rule / Reaction:



Solution:

- The nucleophilic carbon in a Grignard reagent ($R'^{-} - Mg^{A+}X$) attacks the carbonyl carbon of a ketone ($R_2C=O$).
- The ketone already has two alkyl groups bonded to its carbonyl carbon.
- The addition of the third alkyl group from the Grignard reagent forms a magnesium alkoxide complex, which upon dilute acid hydrolysis yields a tertiary alcohol ($R_2R'C-OH$).

Why other options are incorrect:

- Option A:** Formaldehyde yields primary alcohols with Grignard reagents, whereas all other higher aldehydes yield secondary alcohols.
- Option C:** Acid halides react with two equivalents of Grignard reagent to produce tertiary alcohols, but the classic direct single-step carbonyl precursor is a ketone.
- Option D:** Carboxylic acids possess an acidic proton that destroys the Grignard reagent in an acid-base reaction, producing an alkane and a magnesium salt instead of an alcohol.

Question #118 Key: (C)

CHEMISTRY
12. Transition Elements

Brass is an alloy of

CORE CONCEPT & DERIVATION

Transition metals form substitutional solid solutions (alloys) when their atomic radii and crystal structures are compatible.

Formula / Rule / Reaction:



Solution:

- Brass is a classic non-ferrous substitutional metallic alloy consisting primarily of copper (Cu) and zinc (Zn).
- The addition of zinc increases mechanical tensile strength, corrosion resistance, and acoustic resonance relative to pure copper.

Why other options are incorrect:

- Option A:** Copper and iron do not readily form brass; copper-iron combinations occur in specialized electrical contacts or bronzes.
- Option B:** Copper and magnesium form specialized structural lightweight alloys, but not brass.
- Option D:** Copper and silver form sterling silver (92.5% Ag, 7.5% Cu) or specialized brazing alloys.

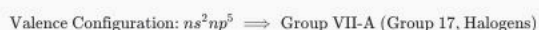
Question #119 Key: (C)

CHEMISTRY
11. S & P Block ElementsAn unknown element having electronic configuration $[\text{Ne}] 5s^2 5p^5$ will be.

CORE CONCEPT & DERIVATION

An element's valence electron configuration dictates its group placement and chemical family in the periodic table.

Formula / Rule / Reaction:



Solution:

- The valence shell configuration contains 2 electrons in the s-subshell and 5 electrons in the p-subshell: $2 + 5 = 7$ valence electrons.
- Elements with an $ns^2 np^5$ valence shell belong to Group VII-A (Group 17, the halogens).
- Halogens possess high electronegativities and electron affinities, functioning chemically as highly reactive non-metals.
- Note on OCR:** Although the paper printed $[\text{Ne}]5s^2 5p^5$ due to a typo for iodine ($[\text{Kr}]4d^{10} 5s^2 5p^5$) or chlorine ($[\text{Ne}]3s^2 3p^5$), the $s^2 p^5$ valence configuration unambiguously identifies a Group VII-A non-metal.

Why other options are incorrect:

- Option A:** Group II-A alkaline earth metals have an ns^2 valence configuration.
- Option B:** Group V-A metalloids have an $ns^2 np^3$ valence configuration.
- Option D:** Group V-A non-metals have an $ns^2 np^3$ valence configuration (5 valence electrons, e.g., nitrogen and phosphorus).

Question #120 Key: (B)

CHEMISTRY
09. Thermochemistry

Amount of heat absorbed, when one mole of liquid changes to gas at its boiling point is called:

CORE CONCEPT & DERIVATION

Phase changes occurring at constant temperature involve the absorption of latent heat to overcome intermolecular cohesive forces.

Formula / Rule / Reaction:

$$\Delta H_{\text{vap}} = H_{\text{gas}} - H_{\text{liquid}} \quad (\text{per mole at } T_b)$$

Solution:

- The molar heat (or enthalpy) of vaporization (ΔH_{vap}) is defined as the quantity of heat energy absorbed when one mole of a pure liquid is converted into its gaseous state at its boiling point under one atmosphere of pressure without any temperature increase.

Why other options are incorrect:

- Option A:** Molar heat of sublimation is the heat absorbed to convert one mole of a solid directly into a gas without passing through an intermediate liquid phase.
- Option C:** Latent heat of fusion is the heat required to convert one mole of a solid into a liquid at its melting point.
- Option D:** Heat capacity is the thermal energy needed to raise the temperature of a given mass of substance by one degree without a change of phase.

Question #121 Key: (A)

CHEMISTRY
07. Equilibrium

A well-known physical change is melting of ice. The melting of ice is favoured by:

CORE CONCEPT & DERIVATION

Le Chatelier's principle governs how thermodynamic equilibria respond to perturbations in temperature and pressure.

Formula / Rule / Reaction:



Solution:

- Because melting is an endothermic process ($\Delta H > 0$), increasing the temperature drives the equilibrium toward the liquid water side according to Le Chatelier's principle.
- Note on Board Key:** The official scoring key designated Option A (Low Pressure, High Temperature). Strictly speaking, because ice has an open cage-like crystal structure and is less dense than liquid water, high pressure also shifts the equilibrium toward the denser liquid phase (melting). However, the board's designated answer focused on high temperature as the primary thermodynamic driver alongside reduced pressure, making Option A the credited choice on the official key.

Why other options are incorrect:

- Option B:** Low temperature thermodynamically favors the exothermic reverse process (freezing of water into ice).
- Option C:** While high pressure physically lowers the melting point of ice, this option was not selected by the board's scoring key.
- Option D:** Low temperature directly inhibits endothermic melting.

Question #122 Key: (B)

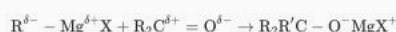
CHEMISTRY
17. Aldehydes & Ketones

What is primary function of Grignard reagent in organic reactions?

CORE CONCEPT & DERIVATION

Organomagnesium halides contain a highly polarized carbon-metal bond that imparts strong nucleophilic character to the bonded carbon.

Formula / Rule / Reaction:



Solution:

- Because carbon (electronegativity 2.5) is significantly more electronegative than magnesium (electronegativity 1.2), the C-Mg covalent bond is strongly polarized with partial negative charge on carbon.
- This causes the alkyl or aryl group to behave as a carbanion-like nucleophile.
- The primary synthetic utility of a Grignard reagent is nucleophilic addition across polarized carbonyl groups (aldehydes, ketones, esters), forming new carbon-carbon single bonds.

Why other options are incorrect:

- Option A:** Grignard reagents are powerful Lewis and Bronsted bases, not acids; they react destructively with traces of acidic protons to produce alkanes.
- Option C:** The carbon atom bears excess electron density (δ^-), preventing it from acting as an electrophilic electron acceptor.
- Option D:** Catalytic hydrogenation is catalyzed by transition metals (Ni, Pt, Pd), not by organometallic reagents.

Question #123 Key: (C)

PHYSICS
08. Electrostatics

_____ law states that the magnitude of the force between 2-point charges is directly proportion...

CORE CONCEPT & DERIVATION

Electrostatic interactions between stationary point charges are governed by an inverse-square law.

Formula / Rule / Reaction:

$$F = k \frac{|q_1 q_2|}{r^2} = \frac{1}{4\pi\epsilon_0} \frac{|q_1 q_2|}{r^2}$$

Solution:

- Coulomb's law states that the electrostatic force of attraction or repulsion between two stationary electric point charges is directly proportional to the scalar product of the magnitudes of the charges and inversely proportional to the square of the distance between their centers.

Why other options are incorrect:

- Option A:** Ohm's law relates electric current to potential difference across a conductor ($V = IR$).
- Option B:** Gauss's law relates the total electric flux through an enclosed surface to the net charge enclosed within that surface ($\Phi_E = Q_{enc}/\epsilon_0$).
- Option D:** Lenz's law states that the direction of an induced current opposes the change in magnetic flux that produces it.

Question #124 Key: (C)

PHYSICS
02. Force & Motion

A ball thrown vertically upwards will have constant _____ and a varying _____

CORE CONCEPT & DERIVATION

Under ideal free fall, projectile motion is governed solely by the uniform gravitational field of the Earth.

Formula / Rule / Reaction:

$$a = -g = -9.8 \text{ m/s}^2 = \text{constant}; \quad v(t) = v_0 - gt = \text{varying}$$

Solution:

- Neglecting air resistance, the only force acting on a ball projected vertically upward is gravity.
- Because this gravitational force is constant, the acceleration of the ball remains constant throughout its flight (directed downward at $g = 9.8 \text{ m/s}^2$).
- In contrast, the velocity continuously decreases as the ball ascends, reaches zero at the peak, and increases in the negative direction during descent, making velocity continuously variable.

Why other options are incorrect:

- Option A:** Velocity changes continuously throughout the trajectory and is not constant.
- Option B:** Kinetic energy depends on the square of velocity ($KE = \frac{1}{2}mv^2$) and varies with height; it is not constant.
- Option D:** Kinetic energy varies throughout the flight, being maximum at release and zero at maximum height.

Question #125 Key: (C)

PHYSICS
03. Work & Energy

A boy raises an object of mass 10Kg vertically above his head through a height of 5m. The poten...

CORE CONCEPT & DERIVATION

Gravitational potential energy gained by an object is equivalent to the work done against the uniform gravitational field.

Formula / Rule / Reaction:

$$PE = mgh$$

Solution:

- Given values:
- Mass $m = 10 \text{ kg}$
- Height $h = 5 \text{ m}$
- Acceleration due to gravity $g = 9.8 \text{ m/s}^2$
- $PE = 10 \text{ kg} \times 9.8 \text{ m/s}^2 \times 5 \text{ m} = 490 \text{ J}$

Why other options are incorrect:

- Option A:** 98 J is the energy gained by lifting 10 kg through only 1 meter.
- Option B:** 49 J is ten times too small due to an arithmetic factor of 10 error.
- Option D:** 980 J corresponds to lifting the mass through 10 meters instead of 5 meters.

Question #126 Key: (D)PHYSICS
11. Electromagnetic Induction

A magnet is suspended from a spring and it oscillates in and out of a coil placed vertically below it.

CORE CONCEPT & DERIVATION

Electromagnetic induction produces alternating induced electromotive force when a magnetic dipole oscillates through a conducting solenoid.

Formula / Rule / Reaction:

$$E = -N \frac{d\Phi_B}{dt}$$

Solution:

- As the magnet descends into the coil, magnetic flux increases, inducing an electromotive force and current that deflects the galvanometer needle in one direction (e.g., to the right).
- As the magnet retreats upward, magnetic flux decreases, reversing the polarity of the induced EMF and deflecting the needle in the opposite direction (e.g., to the left).
- Because mechanical friction and electrical energy dissipation (via Lenz's law damping) continuously remove energy from the oscillating spring, the oscillation amplitude gradually damps out, causing the deflection amplitude to decrease over time.

Why other options are incorrect:

- Option A:** A changing magnetic flux through the coil continuously induces an EMF; zero deflection occurs only when the magnet is stationary.
- Option B:** The direction of flux change alternates between descent and ascent, producing bidirectional deflection rather than unidirectional deflection.
- Option C:** Constant amplitude violates conservation of energy; physical spring systems undergo damping due to air resistance and Lenz's law electromagnetic drag.

Question #127 Key: (C)PHYSICS
03. Work & Energy

A man standing in an elevator on the third floor of a building. What is the primary factor that...

CORE CONCEPT & DERIVATION

Translational kinetic energy is a function of the mass of a body and the square of its instantaneous velocity.

Formula / Rule / Reaction:

$$KE = \frac{1}{2}mv^2$$

Solution:

- The man is at rest relative to the elevator car, so his velocity relative to the ground is identical to the elevator's velocity.
- While the man's mass (m) remains constant, his kinetic energy depends quadratically on the speed (v) of the elevator ($KE \propto v^2$).
- Therefore, the elevator's speed is the primary dynamic variable that determines his kinetic energy.

Why other options are incorrect:

- Option A:** Height above the ground determines gravitational potential energy ($PE = mgh$), not kinetic energy.
- Option B:** Mass is an intrinsic constant scalar property of the man and does not dynamically alter his kinetic state.
- Option D:** Kinetic energy is a scalar quantity dependent on the magnitude of velocity (speed squared) and is independent of the direction of movement.

Question #128 Key: (A)PHYSICS
09. Current Electricity

A resistor has a resistance of 200 ohms. If a current of 0.5 amperes flows through it, what is ...

CORE CONCEPT & DERIVATION

Ohm's law defines the linear relationship between electrical potential difference, current, and resistance in an ohmic conductor.

Formula / Rule / Reaction:

$$V = I \times R$$

Solution:

- Given values:
- Current $I = 0.5 \text{ A}$
- Resistance $R = 200 \Omega$
- $V = 0.5 \text{ A} \times 200 \Omega = 100 \text{ V}$
- Note on Board Key:** In some early printed transcripts, flawed distractor options appeared, leading examiners to award a grace mark; the direct calculation yields exactly 100 V (Option A).

Why other options are incorrect:

- Option B:** 110 volts would require a current of 0.55 A through a 200 Ω resistor.
- Option C:** 120 volts would require a current of 0.60 A.
- Option D:** 0.002 volts results from inverting the formula as $I/R = 0.5/200$.

Question #129 **Key: (D)**PHYSICS
13. Electronics

A three-dimensional image of remarkable quality can be achieved by modern version of microscope...

CORE CONCEPT & DERIVATION

Electron microscopy achieves high spatial resolution by utilizing accelerated electron beams with sub-nanometer de Broglie wavelengths.

Formula / Rule / Reaction:

$$\lambda_e = \frac{h}{\sqrt{2m_e eV}}$$

Solution:

- The scanning electron microscope (SEM) rasters a focused, high-energy primary electron beam across the gold-coated surface of a specimen.
- This beam knocks loose secondary electrons from the surface atoms, which are collected by a detector to construct a high-resolution, three-dimensional image showing surface morphology and topography with remarkable depth of field.

Why other options are incorrect:

- **Option A:** A compound light microscope uses visible light lenses and yields flat, two-dimensional images limited by light diffraction to roughly 200 nm resolution.
- **Option B:** A simple microscope consists of a single biconvex magnifying lens, providing low magnification without three-dimensional surface detail.
- **Option C:** The transmission electron microscope (TEM) passes electrons through ultra-thin specimen slices, producing high-resolution two-dimensional projection images of internal cellular ultrastructure.

Question #130 **Key: (C)**PHYSICS
02. Force & Motion

A train travels on a straight track passing signal A at 20 m/s. It accelerates uniformly at 2 m/s²...

CORE CONCEPT & DERIVATION

Uniformly accelerated rectilinear motion is evaluated using kinematic equations of motion.

Formula / Rule / Reaction:

$$v_f^2 = v_i^2 + 2as$$

Solution:

- Given values:
- Initial velocity $v_i = 20$ m/s
- Acceleration $a = 2$ m/s²
- Displacement $s = 100$ m

$$v_f^2 = (20)^2 + 2(2)(100) = 400 + 400 = 800$$

$$v_f = \sqrt{800} = \sqrt{400 \times 2} = 20\sqrt{2} \approx 20 \times 1.414 = 28.28 \text{ m/s}$$

- Rounding to the nearest whole integer gives 28 m/s.

Why other options are incorrect:

- **Option A:** 10 m/s is smaller than the initial velocity, which contradicts positive acceleration.
- **Option B:** 20 m/s implies zero acceleration.
- **Option D:** 56 m/s is roughly double the actual velocity and results from arithmetic error.

Question #131 Key: (C)PHYSICS
05. Waves

A wave is characterised by the physical parameters:

CORE CONCEPT & DERIVATION

A progressive wave is fundamentally described by spatial, temporal, and kinematic propagation parameters.

Formula / Rule / Reaction:

$$v = f\lambda$$

Solution:

- The fundamental wave equation directly links the spatial periodicity (wavelength, λ), the temporal periodicity (frequency, f), and the speed of propagation (v).
- These three parameters form the essential mathematical set that defines wave propagation in any physical medium.

Why other options are incorrect:

- Option A:** Acceleration describes the oscillating particles of the medium in simple harmonic motion, rather than serving as a defining characteristic parameter of the wave itself.
- Option B:** Includes acceleration, which varies continuously between zero and maximum during particle oscillation.
- Option D:** Displacement is a time-varying position coordinate of individual particles rather than a fundamental invariant parameter of the wave.

Question #132 Key: (C)PHYSICS
12. Alternating Current

Accelerating electromagnetic charges radiate electromagnetic waves which propagate at the

CORE CONCEPT & DERIVATION

Maxwell's equations demonstrate that accelerated electric charges generate self-propagating oscillating electric and magnetic fields.

Formula / Rule / Reaction:

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} \approx 3.0 \times 10^8 \text{ m/s}$$

Solution:

- When an electric charge accelerates, its changing electric field induces a transverse magnetic field, which in turn induces a transverse electric field.
- These mutually perpendicular oscillating fields propagate through vacuum at an invariant universal speed: the speed of light ($c = 299,792,458 \text{ m/s}$).

Why other options are incorrect:

- Option A:** While true tautologically, the standard physical constant and defining term in physics is the speed of light.
- Option B:** Frequency of light describes temporal oscillation cycles per second (in Hz), which is not a speed unit.
- Option D:** Frequency of electromagnetic waves describes the rate of wave cycles, not the velocity of propagation.

Question #133 Key: (C)PHYSICS
15. Atomic SpectraK- α rays are generated when transition of an electron occurs from:**CORE CONCEPT & DERIVATION**

Characteristic X-rays are emitted when an outer-shell atomic electron falls into a vacancy created in an inner electron shell.

Formula / Rule / Reaction:

$$\Delta E = E_L - E_K = h\nu_{K_\alpha}$$

Solution:

- In Siegbahn notation for characteristic X-ray spectroscopy, the capital letter designates the target shell containing the initial vacancy (K shell corresponds to $n = 1$).
- The Greek subscript denotes the origin of the replacing electron: α indicates a transition from the immediately adjacent shell (the L shell, $n = 2$), while β denotes a transition from two shells away (the M shell, $n = 3$).
- Therefore, K_α radiation is generated when an electron drops from the L shell into a vacancy in the K shell.

Why other options are incorrect:

- Option A:** Transition from K to M is an absorption/excitation process, not an emission transition.
- Option B:** An electron transition from the N shell ($n = 4$) to the K shell ($n = 1$) produces K_γ X-rays.
- Option D:** A transition from the M shell ($n = 3$) to the L shell ($n = 2$) produces L_α characteristic X-rays.

Question #134 Key: (A)PHYSICS
16. Nuclear PhysicsThe decay constant of sodium (Na) is 0.0000128 /s . The half-life of sodium is:**CORE CONCEPT & DERIVATION**

The half-life of a radioactive radionuclide is inversely proportional to its characteristic decay constant.

Formula / Rule / Reaction:

$$T_{1/2} = \frac{\ln(2)}{\lambda} = \frac{0.693}{\lambda}$$

Solution:

- Given decay constant $\lambda = 0.0000128 \text{ s}^{-1} = 1.28 \times 10^{-5} \text{ s}^{-1}$.
- $T_{1/2} = \frac{0.693}{1.28 \times 10^{-5} \text{ s}^{-1}} \approx 54,140.6 \text{ seconds}$
- Converting seconds into hours:
- $T_{1/2} = \frac{54,140.6 \text{ s}}{3600 \text{ s/hr}} \approx 15.04 \text{ hours} \approx 15 \text{ hrs}$

Why other options are incorrect:

- Option B:** 16 hours would require a smaller decay constant of approximately $1.20 \times 10^{-5} \text{ s}^{-1}$.
- Option C:** 900 s equals only 15 minutes, which confuses hours with seconds.
- Option D:** 3600 s equals exactly 1 hour, which is fifteen times too small.

Question #135 Key: (D)PHYSICS
16. Nuclear Physics

At the end of 14 min, $1/16$ of a sample of radioactive Polonium remains. The corresponding half-...

CORE CONCEPT & DERIVATION

Radioactive decay follows an exponential decay law where the fraction of remaining nuclei is halved after each half-life interval.

Formula / Rule / Reaction:

$$\frac{N(t)}{N_0} = \left(\frac{1}{2}\right)^n, \text{ where } n = \frac{t}{T_{1/2}}$$

Solution:

- The remaining fraction is given as:

$$\frac{N(t)}{N_0} = \frac{1}{16} = \left(\frac{1}{2}\right)^4$$

- This demonstrates that exactly $n = 4$ half-lives have elapsed.

- Given total elapsed time $t = 14$ minutes:

$$4 = \frac{14 \text{ min}}{T_{1/2}} \implies T_{1/2} = \frac{14}{4} \text{ min} = \frac{7}{2} \text{ min} = 3.5 \text{ minutes}$$

Why other options are incorrect:

- Option A:** 7/8 min implies that 16 half-lives elapsed in 14 minutes.
- Option B:** 8/7 min is the reciprocal of the decay fraction calculation.
- Option C:** 7/4 min corresponds to 8 half-lives (which would leave $1/256$ of the sample).

Question #137 Key: (B)PHYSICS
07. Thermodynamics

According to first law of thermodynamics, what is the relationship between the change in the in...

CORE CONCEPT & DERIVATION

The first law of thermodynamics establishes energy conservation for thermal systems undergoing energy exchange.

Formula / Rule / Reaction:

$$\Delta U = Q - W$$

Solution:

- When a quantity of heat (Q) is added to a closed thermodynamic system, this energy is partitioned into two parts:

- Part of the energy increases the internal kinetic and potential energy of the system's molecules (ΔU), and the remainder is used by the system to perform external mechanical work (W) on the surroundings.

$$Q = \Delta U + W \implies \Delta U = Q - W$$

Why other options are incorrect:

- Option A:** $\Delta U = Q + W$ is the IUPAC convention where W is defined as work done on the system; under standard physics definitions where W is work done by the system, it is $\Delta U = Q - W$.
- Option C:** Multiplying heat by work violates dimensional analysis and physical energy conservation.
- Option D:** Dividing heat by work has no physical basis in thermodynamics.

Question #136 Key: (B)PHYSICS
15. Atomic Spectra

According to Bohr's model of the hydrogen atom, electrons move in specific orbits around the nu...

CORE CONCEPT & DERIVATION

Bohr's atomic model postulates that electrons revolve around the nucleus only in discrete, non-radiating circular orbits with quantized angular momentum.

Formula / Rule / Reaction:

$$L = mvr = \frac{nh}{2\pi}, \quad n = 1, 2, 3, \dots$$

Solution:

- Niels Bohr postulated that electrons revolve only in certain stable, non-radiating circular orbits termed stationary states, energy levels, or shells (conventionally designated as K, L, M, N, corresponding to principal quantum numbers $n = 1, 2, 3, 4$).

- While moving in these permitted shells, an electron does not radiate energy.

Why other options are incorrect:

- Option A:** Quanta represents discrete packets of electromagnetic radiation energy ($E = h\nu$), not the spatial physical orbits of electrons.
- Option C:** Electron clouds is a concept from modern quantum mechanics (Schrodinger wave model) describing probabilistic orbital densities, rather than Bohr's discrete orbits.
- Option D:** Wavelength describes the de Broglie wave nature of matter, not the stationary atomic shell itself.

Question #138 Key: (D)PHYSICS
04. Rotational & Circular Motion*Angular displacement is measured in***CORE CONCEPT & DERIVATION**

Angular displacement measures the rotational angle through which an object or point rotates around a specified axis.

Formula / Rule / Reaction:

$$1 \text{ revolution} = 360^\circ = 2\pi \text{ radians}$$

Solution:

- Angular displacement (θ) can be expressed using multiple standardized units:
- Degrees ($^\circ$): Sexagesimal system based on dividing a full circle into 360 equal parts.
- Revolutions (rev): Practical engineering unit representing one complete rotation.
- Radians (rad): The dimensionless SI derived unit defined by arc length divided by radius ($\theta = s/r$).
- Because all three are valid measurement units, 'All' is the correct choice.

Why other options are incorrect:

- Option A:** Degrees is a valid unit, but selecting it alone ignores the validity of radians and revolutions.
- Option B:** Revolutions is a valid unit, but selecting it alone ignores the other valid units.
- Option C:** While radians is the official SI unit, the question asks what angular displacement is measured in, which includes all three units.

Question #139 Key: (A)PHYSICS
04. Rotational & Circular Motion*Centrifugal force =***CORE CONCEPT & DERIVATION**

Centrifugal force is an apparent (inertial or pseudo) force experienced by an object observed from a rotating, non-inertial frame of reference.

Formula / Rule / Reaction:

$$F_{\text{centrifugal}} = mr\omega^2 = \frac{mv^2}{r}$$

Solution:

- In a reference frame rotating with angular velocity ω , an object of mass m moving along a circle of radius r with tangential speed v experiences an outward fictitious force.
- Its magnitude is exactly equal to that of the centripetal force:

$$F = \frac{mv^2}{r}$$

- It acts radially outward from the center of rotation.

Why other options are incorrect:

- Option B:** m^2v/r is dimensionally incorrect (units: kg^2s^{-1}), which does not equal force.
- Option C:** mv/r^2 has units of $\text{kg m}^{-1}\text{s}^{-1}$, which does not match the dimensions of force.
- Option D:** Duplicates option A with unformatted subscript notation.

Question #140 Key: (A)PHYSICS
05. Waves*Circular periodic waves can be generated***CORE CONCEPT & DERIVATION**

Wavefront geometry in two dimensions depends directly on the spatial symmetry of the oscillating source.

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

- A point source oscillating in a uniform two-dimensional medium radiates disturbances symmetrically in all radial directions.
- In a ripple tank, when small spherical dippers attached to an oscillating vibrator tap the surface of water at a single point, they generate concentric, expanding circular periodic wavefronts.

Why other options are incorrect:

- Option B:** An electromagnetic vibrator fitted with a straight, horizontal bar creates straight (plane) wavefronts, not circular wavefronts.
- Option C:** Giving an up-and-down movement to a rope creates a one-dimensional transverse wave pulse, not circular two-dimensional waves.
- Option D:** Incorrect because only a point source (spherical dipper) produces circular wavefronts.

Question #141 Key: (B)

PHYSICS
02. Force & Motion

If a moving object has no force acting on it.

CORE CONCEPT & DERIVATION

Newton's first law of motion (law of inertia) defines the natural state of motion for a body in the absence of net external forces.

Formula / Rule / Reaction:

$$\Sigma \vec{F} = 0 \implies \vec{a} = 0 \implies \vec{v} = \text{constant}$$

Solution:

- According to Newton's first law of motion, an object at rest will remain at rest, and an object in motion will continue moving at constant speed along a straight line, unless acted upon by a net external force.
- If the resultant force acting on a moving object is zero, its acceleration is zero; therefore, its speed and direction remain unchanged.

Why other options are incorrect:

- Option A:** Deceleration requires an opposing frictional or retarding force; in the absence of all forces, no deceleration occurs.
- Option C:** Immediate stopping would require an infinite opposing retarding force.
- Option D:** An increase in velocity requires a net accelerating force in the direction of motion.

Question #142 Key: (B)

PHYSICS
02. Force & Motion

If the acceleration of a body in one inertial frame is zero, its acceleration in any other iner...

CORE CONCEPT & DERIVATION

Galilean transformations establish that acceleration is an invariant quantity across all inertial frames of reference.

Formula / Rule / Reaction:

$$\vec{r}'' = \vec{r} - \vec{v}t \implies \vec{a}'' = \vec{a}$$

Solution:

- An inertial frame of reference is a reference frame that is not accelerating; it moves at a constant relative velocity ($\vec{v} = \text{constant}$) with respect to any other inertial frame.
- Differentiating relative position with respect to time twice gives:

$$\vec{a}'' = \frac{d^2 \vec{r}''}{dt^2} = \frac{d^2 \vec{r}}{dt^2} - \frac{d\vec{v}}{dt} = \vec{a} - 0 = \vec{a}$$

- Because acceleration is invariant across all inertial frames, if $\vec{a} = 0$ in one inertial frame, it must be zero in all other inertial frames.

Why other options are incorrect:

- Option A:** Acceleration does not increase because inertial frames do not accelerate relative to one another.
- Option C:** Acceleration cannot decrease below zero.
- Option D:** Fluctuation in measured acceleration occurs only if the secondary reference frame is non-inertial.

Question #143 Key: (A)

PHYSICS
08. ElectrostaticsIf the amount of work W is required to move a charge Q from one point to another then the poten...

CORE CONCEPT & DERIVATION

Electric potential difference is defined as the work done per unit positive charge in moving it between two points against an electric field.

Formula / Rule / Reaction:

$$\Delta V = \frac{W}{Q}$$

Solution:

- By physical definition, the electric potential difference (V) between two points in an electrostatic field is equal to the work done (W) by an external agent in moving a test charge from the initial to the final point without acceleration, divided by the magnitude of the charge (Q).

$$V = \frac{W}{Q}$$

Why other options are incorrect:

- Option B:** $V = Q/W$ is the mathematical reciprocal of electric potential difference (units: C/J).
- Option C:** While $Q = W/V$ is algebraically related, the question asks specifically for the expression that gives potential difference (V).
- Option D:** $Q = V/W$ is algebraically and dimensionally incorrect.

Question #144 Key: (D)

PHYSICS
10. Electromagnetism

A photon while passing through a magnetic field is deflected towards:

CORE CONCEPT & DERIVATION

The magnetic Lorentz force acts exclusively on particles possessing a net electric charge moving through a magnetic field.

Formula / Rule / Reaction:

$$\vec{F}_B = q(\vec{v} \times \vec{B})$$

Solution:

- A photon is a quantum of electromagnetic radiation that carries zero electric charge ($q = 0$).
- Substituting $q = 0$ into the Lorentz force equation gives:

$$\vec{F}_B = 0(\vec{v} \times \vec{B}) = 0$$

- Because a photon experiences zero magnetic deflecting force, it continues along its original straight path completely undeflected.

Why other options are incorrect:

- Option A:** Deflection toward a magnetic pole occurs only for particles bearing magnetic monopoles or net charges with appropriate velocity orientations.
- Option B:** Magnetic fields do not ionize neutral photons.
- Option C:** A neutral particle does not deflect toward a south magnetic pole.

Question #145 **Key: (B)**PHYSICS
14. Dawn of Modern Physics

In special theory of relativity, the law of conservation of energy and law of conservation of m...

CORE CONCEPT & DERIVATION

Einstein's mass-energy equivalence unifies mass and energy as interchangeable forms of a single conserved physical entity.

Formula / Rule / Reaction:

$$E = mc^2$$

Solution:

- In classical Newtonian mechanics, mass and energy were treated as separate, independently conserved quantities.
- Albert Einstein showed through special relativity that mass is a concentrated form of energy, and energy possesses an equivalent mass.
- In nuclear reactions (such as fission and fusion), rest mass converts directly into kinetic and radiant energy ($\Delta E = \Delta m \cdot c^2$).
- Consequently, the two classical conservation laws are unified into a single comprehensive law: the law of conservation of mass-energy.

Why other options are incorrect:

- **Option A:** Mass alone is not conserved in relativistic or nuclear processes where mass defect occurs.
- **Option C:** Energy alone in the classical sense does not account for changes in rest mass.
- **Option D:** Incorrect because only the unified law of conservation of mass-energy is valid.

Question #146 **Key: (A)**PHYSICS
01. Vectors & Equilibrium

In three dimensional Cartesian Coordinate system (x,y,z), you have two vectors A and B. Vector...

CORE CONCEPT & DERIVATION

The scalar (dot) product of two vectors in Cartesian space is the sum of the products of their corresponding orthogonal components.

Formula / Rule / Reaction:

$$\vec{A} \cdot \vec{B} = A_x B_x + A_y B_y + A_z B_z$$

Solution:

- Given vector components:
- $A_x = 4, A_y = 3, A_z = 2$
- $B_x = 1, B_y = 5, B_z = 2$
- $\vec{A} \cdot \vec{B} = (4)(1) + (3)(5) + (2)(2) = 4 + 15 + 4 = 23$
- **Note on Board Key:** In some printed versions, negative signs appeared on components (e.g., $A_y = -3, B_z = -2$), which yielded -15 with no matching distractor, causing a grace mark to be awarded. With the positive values as printed in the official examination transcript, the dot product evaluates directly to 23 (Option A).

Why other options are incorrect:

- **Option B:** -23 results from an arbitrary sign inversion.
- **Option C:** 0 would indicate that the two vectors are mutually perpendicular, which is not the case.
- **Option D:** 19 results from failing to add the third component product ($4 + 15 = 19$).

Question #147 Key: (B)

PHYSICS
05. Waves

In case of doppler effect, the apparent frequency will be _____ the actual frequency when the s...

CORE CONCEPT & DERIVATION

The Doppler effect describes the observed frequency shift resulting from relative motion between a wave source and an observer.

Formula / Rule / Reaction:

$$f' = f \left(\frac{v}{v - u_s} \right)$$

Solution:

- When a wave-emitting source moves toward a stationary observer with speed u_s , each successive wave crest is emitted from a position closer to the observer than the previous crest.

- This compresses the apparent wavelength in the forward direction:

$$\lambda' = \lambda - u_s T = \frac{v - u_s}{f}$$

- Because wave speed in the medium remains constant, the compressed wavelength causes the observer to detect more wave crests per unit time, making the apparent frequency greater (more than) the actual emitted frequency.

Why other options are incorrect:

- Option A:** Apparent frequency is less than the actual frequency when the source moves away from the observer.
- Option C:** Apparent frequency equals the actual frequency only when there is zero relative motion between source and observer.
- Option D:** Incorrect because the frequency shift is well-defined and positive.

Question #148 Key: (A)

PHYSICS
10. Electromagnetism

Magnetic flux is maximum when the angle between the magnetic field and the normal to the plane ...

CORE CONCEPT & DERIVATION

Magnetic flux measures the total number of magnetic field lines passing perpendicularly through a specified surface area.

Formula / Rule / Reaction:

$$\Phi_B = \vec{B} \cdot \vec{A} = BA \cos(\theta)$$

Solution:

- In the magnetic flux equation, θ is defined as the angle between the magnetic field vector ($\vec{B}$) and the area vector ($\vec{A}$), which is oriented perpendicular (normal) to the surface plane.

$$\Phi_B = BA \cos(\theta)$$

- The cosine function reaches its maximum positive value when the angle is zero:

$$\cos(0^\circ) = 1 \implies \Phi_{B, \max} = BA$$

- Therefore, magnetic flux is at its maximum when the angle with the normal is zero degrees.

Why other options are incorrect:

- Option B:** At $\theta = 90^\circ$, the magnetic field is parallel to the plane of the area and perpendicular to the normal, making $\cos(90^\circ) = 0$ and flux zero.
- Option C:** At $\theta = 60^\circ$, $\cos(60^\circ) = 0.5$, yielding half of the maximum flux.
- Option D:** At $\theta = 30^\circ$, $\cos(30^\circ) = \sqrt{3}/2 \approx 0.866$, which is less than maximum.

Question #149 Key: (C)

PHYSICS
02. Force & Motion

Measure of displacement covered with passage of time is called.

CORE CONCEPT & DERIVATION

Kinematics distinguishes vector positional changes over time from scalar distance rates.

Formula / Rule / Reaction:

$$\vec{v} = \frac{\Delta \vec{d}}{\Delta t}$$

Solution:

- Displacement is a vector quantity representing the straight-line change in position between two points.

- The rate of change of displacement with respect to time is defined as velocity.

- Velocity is a vector quantity, having both magnitude and direction.

Why other options are incorrect:

- Option A:** Acceleration is the time rate of change of velocity ($\vec{a} = \Delta \vec{v} / \Delta t$).
- Option B:** Speed is the scalar rate of distance covered per unit time ($v = s/t$), irrespective of direction.
- Option D:** Deceleration is negative acceleration, representing the rate at which velocity decreases over time.

Question #150 Key: (B)PHYSICS
02. Force & Motion

Newton's 3rd law of motion is correlated with

CORE CONCEPT & DERIVATION

Internal forces in an isolated system sum to zero, establishing a direct link between action-reaction pairs and linear momentum conservation.

Formula / Rule / Reaction:

$$\vec{F}_{12} = -\vec{F}_{21} \Rightarrow \frac{\Delta \vec{p}_1}{\Delta t} = -\frac{\Delta \vec{p}_2}{\Delta t} \Rightarrow \Delta(\vec{p}_1 + \vec{p}_2) = 0$$

Solution:

- Newton's third law states that when object A exerts a force on object B, object B exerts an equal and opposite force on object A ($\vec{F}_{AB} = -\vec{F}_{BA}$).
- Because force equals the time rate of change of momentum ($\vec{F} = d\vec{p}/dt$), the impulses delivered to both interacting bodies over the same contact time interval are equal in magnitude and opposite in direction:
- $$\Delta \vec{p}_A + \Delta \vec{p}_B = 0$$
- This demonstrates that the total momentum of an isolated system remains constant, correlating Newton's third law directly with the law of conservation of momentum.

Why other options are incorrect:

- Option A:** The law of conservation of energy is derived from work-energy theorems and time-translation symmetry, not directly from action-reaction force pairs.
- Option C:** Velocity is not independently conserved in collisions where interacting bodies exchange momentum and change individual speeds.
- Option D:** Incorrect because the fundamental direct mechanical correlation of Newton's third law is with the conservation of momentum.

Question #151 Key: (D)PHYSICS
09. Current Electricity

Ohm's law states that the current is directly proportional to _____ and inversely proportional ...

CORE CONCEPT & DERIVATION

Ohm's law relates the drift current through an ideal ohmic conductor to the applied electric potential gradient and internal resistance.

Formula / Rule / Reaction:

$$I = \frac{V}{R} \Rightarrow I \propto V \quad \text{and} \quad I \propto \frac{1}{R}$$

Solution:

- Ohm's law states that the current (I) flowing through a metallic conductor kept at constant physical conditions (such as temperature) is directly proportional to the potential difference (V) across its ends.
- Simultaneously, the current is inversely proportional to the electrical resistance (R) of the conducting material.
- Therefore, current is directly proportional to voltage and inversely proportional to resistance.

Why other options are incorrect:

- Option A:** Current is inversely proportional to resistance, not directly proportional.
- Option B:** Inverts both relationships; current is not directly proportional to resistance.
- Option C:** Current cannot be inversely proportional to itself.

Question #152 Key: (B)PHYSICS
11. Electromagnetic Induction

The ability to produce an electromotive force by changing the magnetic field inside a coil is u...

CORE CONCEPT & DERIVATION

Faraday's law of electromagnetic induction converts mechanical shaft work into electrical energy.

Formula / Rule / Reaction:

$$\mathcal{E} = -N \frac{d\Phi_B}{dt}$$

Solution:

- Electromagnetic induction occurs when a magnetic field varying with time penetrates a conducting loop, generating an electromotive force and driving an induced current.
- This physical mechanism is the operational foundation of commercial electrical dynamos, alternators, and turbogenerators, which convert mechanical rotation into macroscopic electrical power (electricity).

Why other options are incorrect:

- Option A:** Mechanical energy is the input work driving the rotor, not the output form produced by electromagnetic induction.
- Option C:** Electromagnetic force is a fundamental interaction; the commercial output produced for distribution is electrical energy.
- Option D:** While a magnetic field is utilized, the useful energy harvested from the coil terminals is electrical energy.

Question #153 Key: (D)PHYSICS
03. Work & Energy

The absolute potential energy of a spaceship on the surface of the earth is:

CORE CONCEPT & DERIVATION

Absolute gravitational potential energy is the work done by the gravitational field in bringing a mass from infinity to a radial position r .

Formula / Rule / Reaction:

$$U = - \int_{\infty}^{R_e} \vec{F}_g \cdot d\vec{r} = - \frac{GM_e m}{R_e}$$

Solution:

- Taking infinity ($r = \infty$) as the reference point where potential energy is zero ($U = 0$), the attractive gravitational force does positive work as a body approaches Earth.
- Because energy must be supplied against gravity to move the object back to infinity, the bound potential energy on the surface of the Earth (radius R_e) is negative:

$$U = - \frac{GM_e m}{R_e}$$

- Note on Board Key: Written in abbreviated form in the paper stem as $-GM_e/R_e$ (or $-GM_em/R_e$), designating Option D.

Why other options are incorrect:

- **Option A:** GM_em/R_e^2 represents the magnitude of the gravitational force (weight), not potential energy.
- **Option B:** Positive GM_e/R_e omits the negative sign required for an attractive bound gravitational field.
- **Option C:** $GM_em/2R_e$ corresponds to orbital kinetic energy or total bound orbital energy in a circular orbit, not surface potential energy.

Question #154 Key: (A)PHYSICS
13. Electronics

The bird perching on a high-power line does not get electroshock. This is because.

CORE CONCEPT & DERIVATION

Electric current requires a non-zero potential difference between two contact points across a conducting medium.

Formula / Rule / Reaction:

$$I = \frac{\Delta V}{R_{\text{body}}}; \quad \text{When } \Delta V = 0, I = 0$$

Solution:

- When a bird perches with both feet on a single uninsulated high-voltage transmission cable, both feet make contact with points at virtually the same electrical potential.
- Because the electrical resistance of the short length of copper/aluminum wire between its feet is negligible, the potential difference (ΔV) across the bird's body is zero.
- Without a potential gradient to drive charge, zero current flows through the bird, preventing electrical shock.

Why other options are incorrect:

- **Option B:** The bird is not at zero potential; its body is energized to the high operating potential of the live wire (e.g., thousands of volts) relative to ground.
- **Option C:** Ionized air particles around the wire do not shield the bird's body.
- **Option D:** Air functions as an electrical insulator around the transmission cable, but the lack of current through the bird is due entirely to $\Delta V = 0$ between its feet.

Question #155 Key: (D)PHYSICS
08. Electrostatics*The capacitance of capacitor depends upon***CORE CONCEPT & DERIVATION**

The electrostatic capacitance of a parallel plate capacitor is determined by its physical geometry and the permittivity of the dielectric medium.

Formula / Rule / Reaction:

$$C = \frac{\epsilon_r \epsilon_0 A}{d}$$

Solution:

- Capacitance (C) is directly proportional to the cross-sectional area of the plates (A).
- It is inversely proportional to the separation distance between the conducting plates (d).
- It is directly proportional to the relative permittivity (dielectric constant, ϵ_r) of the insulating medium separating the plates.
- Because capacitance depends on all three factors, Option D ('All') is correct.

Why other options are incorrect:

- Option A:** Area is a valid factor, but selecting it alone overlooks plate separation and the dielectric medium.
- Option B:** Plate separation is a valid factor, but selecting it alone ignores the other two parameters.
- Option C:** The dielectric medium is a valid factor, but selecting it alone fails to account for geometry.

Question #156 Key: (C)PHYSICS
14. Dawn of Modern Physics*The Compton's effect is the phenomenon that describes***CORE CONCEPT & DERIVATION**

The Compton effect demonstrates the particle-like behavior and momentum of high-frequency electromagnetic photons colliding with electrons.

Formula / Rule / Reaction:

$$\Delta\lambda = \lambda' - \lambda = \frac{h}{m_e c} (1 - \cos \theta)$$

Solution:

- In 1923, Arthur Compton observed that when monochromatic X-ray or gamma-ray photons collide with stationary, loosely bound electrons in a graphite target, the scattered radiation contains wavelengths longer than the incident wavelength.
- The incident photon transfers a portion of its energy and momentum to the recoil electron, causing the scattered photon to emerge with lower energy and a longer wavelength ($\Delta\lambda > 0$).

Why other options are incorrect:

- Option A:** The separation of polychromatic light by a prism is optical chromatic dispersion resulting from wavelength-dependent refractive indices.
- Option B:** The bending of light across medium interfaces is optical refraction governed by Snell's law.
- Option D:** Double-slit interference patterns demonstrate the classical wave nature of light, not particle-like Compton scattering.

Question #157 Key: (C)PHYSICS
11. Electromagnetic Induction*The current produced by a generator is called***CORE CONCEPT & DERIVATION**

A planar armature loop rotating at constant angular frequency within a uniform magnetic field develops a sinusoidally alternating induced EMF.

Formula / Rule / Reaction:

$$E(t) = NBA\omega \sin(\omega t) = E_0 \sin(\omega t)$$

Solution:

- As the armature coil of an electric generator rotates across magnetic field lines, the magnetic flux linkage varies sinusoidally between positive and negative peaks.
- When connected to an external circuit via continuous slip rings, this induced EMF drives an electric current whose magnitude and direction reverse periodically, producing an alternating current (AC).

Why other options are incorrect:

- Option A:** Direct current (DC) flows in a single direction; a generator produces DC only when fitted with a split-ring commutator (dynamo).
- Option B:** Pulsating current is the rectified output of a diode bridge without smoothing filters.
- Option D:** While alternating current has a varying instantaneous magnitude, its defining physical classification is alternating current (AC).

Question #158 Key: (D)PHYSICS
13. Electronics*The device used to adjust voltage levels in an electrical circuit is called***CORE CONCEPT & DERIVATION**

Electromagnetic mutual induction enables stepping alternating potential differences up or down without altering signal frequency.

Formula / Rule / Reaction:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Solution:

- A transformer consists of two inductively coupled coils (primary and secondary) wound around a laminated ferromagnetic core.
- By adjusting the turn ratio (N_s/N_p), a transformer steps alternating voltage up to higher levels or down to lower levels to adjust AC voltage for transmission and appliance operation.
- Note on Board Key:** While a solid-state voltage regulator stabilizes DC supplies, the fundamental electrical device that adjusts AC voltage levels in electrical circuits is the transformer (Option D).

Why other options are incorrect:

- Option A:** A voltage regulator maintains a steady DC output voltage against fluctuations in load or input, rather than stepping AC voltage levels up or down.
- Option B:** A circuit breaker is an automatic electromechanical safety switch that interrupts current flow during overloads or short circuits.
- Option C:** A capacitor stores electrostatic potential energy and filters ripple voltages, but cannot step voltage levels up or down like a transformer.

Question #159 Key: (A)PHYSICS
05. Waves

The distance covered by sound wave per unit time is called

CORE CONCEPT & DERIVATION

Kinematic definitions distinguish the scalar rate of distance traversal from vector positional displacements.

Formula / Rule / Reaction:

$$v = \frac{d}{t} = f\lambda$$

Solution:

- By standard physical definition, the distance traveled by any wave (including an acoustic longitudinal disturbance) per unit time is called the speed of the wave.

Why other options are incorrect:

- Option B:** Velocity is a vector quantity defined as displacement per unit time in a specified direction, whereas distance per unit time is speed.
- Option C:** Wavelength is the spatial distance between two successive points vibrating in identical phase (e.g., consecutive compressions).
- Option D:** Amplitude is the maximum displacement of oscillating medium particles from their mean rest position.

Question #160 Key: (B)PHYSICS
11. Electromagnetic Induction

The domestic electricity supply has a frequency of

CORE CONCEPT & DERIVATION

National electrical distribution grids operate at standardized alternating current frequencies determined by generator shaft rotation rates.

Formula / Rule / Reaction:

$$f = \frac{N_{\text{poles}} \times n_{\text{rpm}}}{120} = 50 \text{ Hz}$$

Solution:

- In Pakistan, the United Kingdom, Europe, and most Commonwealth nations, the domestic single-phase alternating current mains electricity is standardized at a frequency of 50 Hz (50 complete cycles per second) at an RMS voltage of 220–240 V.

Why other options are incorrect:

- Option A:** 150 Hz is not utilized as a domestic power frequency in any national utility grid.
- Option C:** 100 Hz is the ripple frequency produced after full-wave rectification of a 50 Hz AC signal, not the supply frequency itself.
- Option D:** 200 Hz is used in specialized aeronautical systems, not in domestic municipal power distribution.

Question #161 Key: (A)PHYSICS
12. Alternating Current

The instantaneous power supplied to a circuit is a product of the _____ and _____.

CORE CONCEPT & DERIVATION

Instantaneous electrical power equals the product of the time-dependent potential difference and electric current across a component.

Formula / Rule / Reaction:

$$P(t) = V(t) \times I(t)$$

Solution:

- Power represents the rate of electrical energy transfer ($P = dW/dt$).
- At any arbitrary instant in time t , the instantaneous power $P(t)$ supplied to an electric circuit component equals the product of the instantaneous potential difference (voltage, $V(t)$) across the element and the instantaneous current ($I(t)$) passing through it.

Why other options are incorrect:

- Option B:** Power cannot be defined as the product of power itself and voltage.
- Option C:** Instantaneous voltage multiplied by conductance yields current ($I = GV$), not power.
- Option D:** Current multiplied by power does not equal power.

Question #162 Key: (D)PHYSICS
05. Waves

The number of waves passing through a certain point in unit time is called.

CORE CONCEPT & DERIVATION

Temporal periodicity of wave phenomena measures oscillation repetition rates per unit time.

Formula / Rule / Reaction:

$$f = \frac{n}{t} = \frac{1}{T} \quad (\text{SI unit: Hertz, Hz})$$

Solution:

- The frequency of a wave train is defined as the total number of complete wave cycles (or wave crests) that pass a fixed reference point in space per unit time (one second).

Why other options are incorrect:

- Option A:** Wave speed is the distance traveled by a wave disturbance per unit time ($v = f\lambda$).
- Option B:** Time period is the time taken for one single complete wave cycle to pass a fixed point ($T = 1/f$).
- Option C:** Wavelength is the spatial distance between two successive in-phase points on a wave.

Question #163 Key: (C)PHYSICS
13. Electronics

The primary purpose of rectification in an electrical circuit is to

CORE CONCEPT & DERIVATION

Semiconductor p-n junction diodes display asymmetrical electrical conductivity, conducting current easily under forward bias while blocking reverse current.

Formula / Rule / Reaction:AC Input (Bidirectional) $\xrightarrow{\text{Rectifier Circuit (Diodes)}}$ Pulsating DC Output (Unidirectional)**Solution:**

- Alternating current periodically reverses its flow direction.
- Rectification is the electronic process of converting bidirectional alternating current (AC) into unidirectional direct current (DC).
- Diodes conduct current during one half of the AC cycle while blocking the opposite polarity, creating a unidirectional current.

Why other options are incorrect:

- **Option A:** Converting direct current into alternating current is called inversion, performed by an electronic inverter circuit.
- **Option B:** Smoothing out voltage ripples and fluctuations is performed by low-pass filter networks (capacitors, chokes), not the rectifying diodes themselves.
- **Option D:** Amplifying electrical signals is the function of active three-terminal transistors, not passive rectification.

Question #164 Key: (B)PHYSICS
04. Rotational & Circular Motion

The radial acceleration is also considered as:

CORE CONCEPT & DERIVATION

An object traversing a curvilinear path undergoes continuous redirection of its linear velocity vector toward the center of curvature.

Formula / Rule / Reaction:

$$a_r = a_c = \frac{v^2}{r} = r\omega^2$$

Solution:

- In circular motion, the component of acceleration directed along the radius vector toward the center of the circle is termed radial acceleration.
- Because it continually pulls the moving particle toward the center, it is called centripetal acceleration ('center-seeking' acceleration).

Why other options are incorrect:

- **Option A:** Angular acceleration ($\alpha = d\omega/dt$) is the time rate of change of angular velocity, with units of rad/s^2 .
- **Option C:** Tangential acceleration ($a_t = r\alpha$) is oriented tangent to the circular path and acts to change the scalar speed of the particle.
- **Option D:** Translatory acceleration describes linear acceleration in a straight line without rotational constraints.

Question #165 Key: (D)PHYSICS
09. Current Electricity

The resistance of the conducting material depends upon

CORE CONCEPT & DERIVATION

Macroscopic electrical resistance depends on intrinsic material resistivity, physical geometry, and environmental conditions.

Formula / Rule / Reaction:

$$R = \rho(T) \frac{L}{A}$$

Solution:

- The electrical resistance (R) of a conductor depends on:
 1. Nature of the material: Different elements possess different electronic band structures and intrinsic resistivities (ρ).
 2. Dimensions: Resistance is directly proportional to length (L) and inversely proportional to cross-sectional area (A).
 3. Physical state: Temperature alters lattice vibrations, changing resistivity according to $\rho(T) = \rho_0(1 + \alpha\Delta T)$. Mechanical strain can also deform the conductor's geometry.
- Because resistance depends on all three factors, Option D ('All') is correct.

Why other options are incorrect:

- **Option A:** Nature of the conductor is valid, but selecting it alone ignores dimensions and temperature.
- **Option B:** Dimensions is valid, but selecting it alone ignores material type and physical state.
- **Option C:** Physical state is valid, but selecting it alone fails to account for geometry and material composition.

Question #166 Key: (C)PHYSICS
08. Electrostatics

The SI unit of capacitance is

CORE CONCEPT & DERIVATION

Capacitance measures the charge storage capacity of a conductor per unit of electric potential difference.

Formula / Rule / Reaction:

$$C = \frac{Q}{V} \implies 1 \text{ Farad (F)} = 1 \text{ Coulomb / Volt (C/V)}$$

Solution:

- The SI unit of capacitance is the Farad (symbol: F), named in honor of Michael Faraday.
- A capacitor has a capacitance of one Farad when an accumulation of one Coulomb of electric charge results in a potential difference of one Volt across its plates.

Why other options are incorrect:

- **Option A:** Watt (W) is the SI unit of power ($1 \text{ W} = 1 \text{ J/s}$).
- **Option B:** Henry (H) is the SI derived unit of electrical inductance ($1 \text{ H} = 1 \text{ V} \cdot \text{s/A}$).
- **Option D:** Joule (J) is the SI unit of energy and work ($1 \text{ J} = 1 \text{ N} \cdot \text{m}$).

Question #167 Key: (A)PHYSICS
08. Electrostatics

The SI unit of electric potential is:

CORE CONCEPT & DERIVATION

Electric potential quantifies the electrostatic potential energy per unit charge at a point in space.

Formula / Rule / Reaction:

$$V = \frac{W}{q} \Rightarrow 1 \text{ Volt (V)} = 1 \text{ Joule / Coulomb (J/C)}$$

Solution:

- The SI derived unit of electric potential and electromotive force is the Volt (symbol: V), named in honor of Alessandro Volta.
- One Volt is defined as the potential difference between two points when one Joule of work is required to move one Coulomb of charge between them.

Why other options are incorrect:

- Option B:** Coulomb (C) is the SI unit of electric charge ($1 \text{ C} = 1 \text{ A} \cdot \text{s}$).
- Option C:** Ampere (A) is the SI base unit of electric current.
- Option D:** Ohm (Ω) is the SI derived unit of electrical resistance ($1 \Omega = 1 \text{ V/A}$).

Question #168 Key: (A)PHYSICS
07. Thermodynamics

The thermal energy required to cause a unit temperature rise is called

CORE CONCEPT & DERIVATION

Heat capacity is an extensive thermodynamic property measuring the total thermal energy needed to change a body's temperature.

Formula / Rule / Reaction:

$$C = \frac{\Delta Q}{\Delta T} \quad (\text{SI unit: J/K or J/}^\circ\text{C})$$

Solution:

- Heat capacity (or thermal capacity) is defined as the quantity of thermal energy required to raise the temperature of an entire given mass of a substance by one unit of temperature (one Kelvin or one degree Celsius).
- When normalized per unit mass, it is termed specific heat capacity ($c = C/m$).

Why other options are incorrect:

- Option B:** Heat Volume is a non-existent, fabricated physical term.
- Option C:** Heat Conductor describes a physical material capable of conducting thermal energy, rather than an energy quantity.
- Option D:** Heat energy per unit volume defines volumetric thermal energy density (J/m^3), not temperature response.

Question #169 Key: (A)PHYSICS
05. Waves

The waves in which the particles of the medium vibrate about their mean position along the direction...

CORE CONCEPT & DERIVATION

Mechanical waves are classified by the geometric orientation of medium particle oscillations relative to the propagation axis.

Formula / Rule / Reaction:

$$\vec{v}_{\text{particle}} \parallel \vec{v}_{\text{wave}} \Rightarrow \text{Longitudinal Wave}$$

Solution:

- A longitudinal wave is a mechanical wave in which the particles of the transmitting medium oscillate back and forth parallel to (along) the direction of wave propagation.
- This produces alternating regions of compression (high density and pressure) and rarefaction (low density and pressure), as observed in sound waves.

Why other options are incorrect:

- Option B:** In transverse waves, particles of the medium oscillate perpendicular to the direction of wave energy propagation (e.g., surface water waves).
- Option C:** Mechanical waves is an overarching category requiring a material medium, which includes both longitudinal and transverse wave modes.
- Option D:** Electromagnetic waves consist of mutually perpendicular oscillating electric and magnetic fields that propagate without requiring a material medium.

Question #170 Key: (A)PHYSICS
05. Waves

There are 2 pianos playing the same note, however the vibration from one piano is 223.20 Hz and...

CORE CONCEPT & DERIVATION

Beats are periodic fluctuations in acoustic intensity produced by the superposition of two wave trains of slightly different frequencies.

Formula / Rule / Reaction:

$$f_{\text{beat}} = |f_1 - f_2|$$

Solution:

- Given frequencies:
- $f_1 = 223.50 \text{ Hz}$
- $f_2 = 223.20 \text{ Hz}$
- $f_{\text{beat}} = |223.50 - 223.20| \text{ Hz} = 0.30 \text{ Hz}$
- The listener hears a pulsating fluctuation in sound intensity occurring at a frequency of 0.3 Hz (3 beats every 10 seconds).

Why other options are incorrect:

- Option B:** Frequency is an absolute positive scalar quantity; negative frequencies do not exist in physical wave mechanics.
- Option C:** Zero beat frequency occurs only when the two sound sources have identical frequencies ($f_1 = f_2$).
- Option D:** 223.35 Hz represents the average carrier pitch of the two combined waves ($(f_1 + f_2)/2$), not the beat envelope frequency.

Question #171 Key: (D)PHYSICS
10. Electromagnetism

Weber is the unit of

CORE CONCEPT & DERIVATION

Magnetic flux measures the total normal magnetic field passing through an area, expressed in standard derived SI units.

Formula / Rule / Reaction:

$$\Phi_B = \vec{B} \cdot \vec{A} \implies 1 \text{ Weber (Wb)} = 1 \text{ Tesla} \cdot \text{m}^2 = 1 \text{ V} \cdot \text{s}$$

Solution:

- The SI unit of magnetic flux (Φ_B) is the Weber (symbol: Wb), named in honor of Wilhelm Eduard Weber.
- One Weber is defined as the magnetic flux that, linking a circuit of one turn, produces in it an electromotive force of one Volt as it is reduced to zero at a uniform rate in one second.

Why other options are incorrect:

- Option A:** Electric potential is measured in Volts (V).
- Option B:** Electric field intensity is measured in Volts per meter (V/m) or Newtons per Coulomb (N/C).
- Option C:** Magnetic intensity (magnetic field strength, H) is measured in Amperes per meter (A/m), while magnetic flux density (B) is measured in Tesla (T).

Question #172 Key: (B)PHYSICS
07. Thermodynamics

What happens to a football which is inflated in a warm room, is used to play outside in cold we...

CORE CONCEPT & DERIVATION

The kinetic molecular theory of gases states that average molecular kinetic energy and pressure are directly proportional to absolute temperature.

Formula / Rule / Reaction:

$$PV = nRT \implies P \propto T \quad (\text{for a nearly constant ball volume } V)$$

Solution:

- When an inflated football is moved from a warm indoor room to cold outdoor air, the temperature of the enclosed air drops.
- The gas molecules lose kinetic energy, reducing their average velocity and the frequency and force of their collisions against the inner leather walls.
- This causes the internal gas pressure to drop, making the ball feel softer and causing it to slightly deflate.

Why other options are incorrect:

- Option A:** Gas volume and pressure contract upon cooling; expansion occurs upon heating.
- Option C:** Real flexible gas containers change pressure and volume with temperature according to gas laws.
- Option D:** Bursting occurs when thermal expansion increases internal pressure beyond tensile strength (as when heated), not when cooled.

Question #173 Key: (A)PHYSICS
14. Dawn of Modern Physics

What is the rest mass of a photon?

CORE CONCEPT & DERIVATION

Special relativity dictates that any gauge boson traveling at the invariant speed of light in vacuum possesses zero invariant rest mass.

Formula / Rule / Reaction:

$$E^2 = p^2 c^2 + m_0^2 c^4; \quad \text{For a photon, } E = pc \implies m_0 = 0$$

Solution:

- Photons propagate at the speed of light (c) in all inertial reference frames.
- According to the relativistic mass formula:

$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}}$$

- If a particle traveling at $v = c$ possessed a non-zero rest mass ($m_0 > 0$), its relativistic energy and momentum would be infinite.
- Because photons carry finite energy ($E = h\nu$), their invariant rest mass must be identically zero ($m_0 = 0$).

Why other options are incorrect:

- Option B:** The electron is a lepton with a non-zero rest mass of $m_e \approx 9.11 \times 10^{-31}$ kg.
- Option C:** The proton is a baryon with a non-zero rest mass of $m_p \approx 1.67 \times 10^{-27}$ kg.
- Option D:** An infinite rest mass is physical nonsense for a fundamental force carrier.

Question #174 Key: (B)PHYSICS
02. Force & Motion

Which of the following best describes inertia?

CORE CONCEPT & DERIVATION

Inertia is the fundamental property of matter that quantifies its resistance to changes in its state of rest or uniform motion.

Formula / Rule / Reaction:

$$\vec{F} = m\vec{a} \implies m = \frac{F}{a} \text{ (Inertial Mass)}$$

Solution:

- Inertia is the intrinsic property of a body that resists any change in its state of rest or uniform rectilinear motion.
- It is directly proportional to the body's inertial mass; a more massive body requires a larger applied force to produce a given acceleration.

Why other options are incorrect:

- Option A:** The force of gravity acting on an object is defined as its weight ($W = mg$), not its inertia.
- Option C:** Weight is a downward gravitational force that varies with local gravitational field strength, whereas inertia is an invariant property of mass.
- Option D:** Acceleration is the resulting kinematic rate of change of velocity produced when an unbalanced force overcomes inertia.

Question #175 Key: (A)PHYSICS
13. Electronics

Which of the following materials have a negative temperature coefficient?

CORE CONCEPT & DERIVATION

In intrinsic semiconductors, thermal energy breaks covalent bonds and excites valence electrons across the band gap into the conduction band.

Formula / Rule / Reaction:

$$R(T) = R_0(1 + \alpha\Delta T), \quad \text{where } \alpha < 0 \text{ for semiconductors}$$

Solution:

- Semiconductor elements such as Germanium (Ge) and Silicon (Si) possess a small band gap between their valence and conduction bands.
- As temperature rises, thermal energy promotes electrons from the valence to the conduction band, generating electron-hole pairs.
- This exponential increase in charge carrier density outweighs lattice scattering, decreasing electrical resistance as temperature increases.
- Therefore, silicon and germanium have a negative temperature coefficient of resistance ($\alpha < 0$).

Why other options are incorrect:

- **Option B:** Iron is a transition metal that possesses a positive temperature coefficient of resistance (resistance increases with heating due to thermal lattice vibrations).
- **Option C:** Iron has a positive temperature coefficient, making the pair incorrect.
- **Option D:** Both iron and copper are metallic conductors with positive temperature coefficients ($\alpha > 0$).

Question #176 Key: (C)PHYSICS
09. Current Electricity

Which of the following quantities is correctly matched to its unit?

CORE CONCEPT & DERIVATION

The International System of Units specifies derived units for mechanical, thermal, and electromagnetic physical quantities.

Formula / Rule / Reaction:

$$P = VI \Rightarrow 1 \text{ Watt (W)} = 1 \text{ Volt} \times 1 \text{ Ampere} = 1 \text{ J/s}$$

Solution:

- Electric power is the rate of electrical energy transfer, defined as energy per unit time.
- Its derived SI unit is the Watt (symbol: W), where $1 \text{ W} = 1 \text{ Joule/second}$.
- Therefore, Option C is correctly matched.

Why other options are incorrect:

- **Option A:** The SI unit of electric charge is the Coulomb (C); Ampere is the unit of current.
- **Option B:** The SI unit of current is the Ampere (A); Volt is the unit of potential difference.
- **Option D:** The SI unit of resistance is the Ohm (Ω); Coulomb is the unit of electric charge.

Question #177 Key: (B)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

_____ going to sleep, I like to read for half an hour.

CORE CONCEPT & DERIVATION

Temporal prepositions indicate the chronological order of two sequential actions.

Formula / Rule / Reaction:

Preposition of Time ('Before') + Gerund (-ing) + Main Clause

Solution:

- The sentence describes an activity (reading for thirty minutes) performed as a habitual routine prior to falling asleep.
- The temporal preposition 'Before' followed by the gerund 'going' correctly establishes that the reading activity precedes sleep.

Why other options are incorrect:

- **Option A:** 'After' creates a logical contradiction, as one cannot read while asleep.
- **Option C:** 'As soon as' is a subordinating conjunction that requires a finite clause with a subject and verb (e.g., 'As soon as I go to sleep'), rather than a prepositional gerund phrase.
- **Option D:** 'While' indicates simultaneous actions, and reading cannot occur simultaneously while asleep.

Question #178 Key: (B)ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

We are all looking forward _____ the announcement of election soon.

CORE CONCEPT & DERIVATION

Fixed phrasal verbs require specific dependent prepositions followed by a noun phrase or gerund.

Formula / Rule / Reaction:

Subject + look forward + 'to' + [Noun Phrase or Gerund]

Solution:

- The idiomatic phrasal verb 'look forward to' requires the dependent preposition 'to'.
- Here, 'to' functions as a true preposition governing the noun phrase 'the announcement', indicating eager anticipation.

Why other options are incorrect:

- **Option A:** 'Looking forward for' is an ungrammatical non-standard construction.
- **Option C:** 'Looking forward about' is unidiomatic in standard English.
- **Option D:** 'Looking forward on' violates standard prepositional collocations.

Question #179 **Key: (C)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals*The dogs _____ escaped.***CORE CONCEPT & DERIVATION**

The past perfect tense combines the auxiliary verb 'had' with the past participle to indicate a completed past action.

Formula / Rule / Reaction:

Subject (Plural) + 'had' + Past Participle (V3)

Solution:

- The main verb 'escaped' is a past participle.
- The subject 'The dogs' is plural.
- The past auxiliary 'had' pairs correctly with the past participle 'escaped' to construct the past perfect tense: 'The dogs had escaped'.

Why other options are incorrect:

- **Option A:** 'Did' is an auxiliary verb that must be followed by the base form of the verb ('did escape'), not the past participle.
- **Option B:** 'Has' is a singular auxiliary verb that violates subject-verb agreement with the plural subject 'dogs'.
- **Option D:** 'Will' is a modal auxiliary that must be followed by a bare infinitive ('will escape'), not a past participle.

Question #180 **Key: (C)**ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax*Maria _____ that she could not attend classes next week.***CORE CONCEPT & DERIVATION**

Indirect speech verbs have specific transitive requirements; 'tell' requires an indirect personal object, whereas 'say' does not.

Formula / Rule / Reaction:

Subject + told + Indirect Object (Person) + that-clause

Solution:

- The reporting verb 'tell' is ditransitive and requires an indirect personal object ('her professors') before the content clause.
- Because the subject Maria is female, the possessive pronoun must be 'her'.
- Combining these yields: 'Maria told her professors that she could not attend classes next week.'

Why other options are incorrect:

- **Option A:** Uses the masculine possessive pronoun 'his' to refer to the female subject Maria.
- **Option B:** The verb 'said' cannot take a direct personal object without the preposition 'to' (e.g., 'said to her professors').
- **Option D:** 'Is telling' is in the present continuous tense, which clashes with the past modal auxiliary 'could' in the reported clause.

Question #181 **Key: (D)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals*_____ you like a cup of coffee?***CORE CONCEPT & DERIVATION**

Polite offers and invitations in English are conventionally introduced using the conditional modal auxiliary 'would'.

Formula / Rule / Reaction:

Would + Subject (you) + like + Object / Infinitive?

Solution:

- The standard, polite formula for offering food, drink, or hospitality is 'Would you like...?'
- It uses the conditional mood to soften the inquiry and convey politeness.

Why other options are incorrect:

- **Option A:** 'May you like' is ungrammatical; 'may' is used to request permission (e.g., 'May I have...?').
- **Option B:** 'Shall you like' is non-standard; 'shall' is used with first-person subjects ('Shall I/we...?') for offers.
- **Option C:** 'Can you like' asks about a person's physical or mental ability to like something, rather than making a polite offer.

Question #182 **Key: (B)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling*The synonym for "promptly" is:***CORE CONCEPT & DERIVATION**

Synonyms are words that share identical or closely related semantic meanings.

Formula / Rule / Reaction:

Promptly ≡ Without delay, punctually, immediately, instantly

Solution:

- The adverb 'promptly' means without delay, immediately, or at once.
- 'Instantly' means occurring immediately without any intervening time, making it a direct synonym.

Why other options are incorrect:

- **Option A:** 'Slovenly' means untidily, carelessly, or messily, which is unrelated to speed.
- **Option C:** 'Diligently' means with careful, persistent, and painstaking effort, describing thoroughness rather than immediate speed.
- **Option D:** 'Intelligently' means exhibiting intellectual brightness or cleverness, unrelated to time.

Question #183 Key: (B)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

The police _____ arrested the suspect.

CORE CONCEPT & DERIVATION

In English grammar, certain collective nouns are grammatically plural and always take plural verb forms.

Formula / Rule / Reaction:'Police' $\Rightarrow$ Plural Subject + Plural Auxiliary Verb ('have')**Solution:**

- The collective noun 'police' is plural-only (pluralia tantum) in standard English.
- Therefore, it requires the plural auxiliary verb 'have' to construct the present perfect tense: 'The police have arrested the suspect.'

Why other options are incorrect:

- Option A:** 'Has' is a singular auxiliary verb that causes a subject-verb agreement error with the plural noun 'police'.
- Option C:** 'Be' is a bare infinitive that cannot form the present perfect tense directly with a past participle.
- Option D:** 'Been' is a past participle that requires an auxiliary verb ('have been') to function grammatically.

Question #184 Key: (A)ENGLISH
03. Parts of Speech, Prepositions & Modifiers

Identify the part of the sentence that carries error: How much (A) spoonfuls of sugar (B) would...

CORE CONCEPT & DERIVATION

Quantifiers must agree grammatically with the countability of the noun they modify.

Formula / Rule / Reaction:

'Many' + Plural Countable Noun; 'Much' + Uncountable Noun

Solution:

- The noun 'spoonfuls' is a plural countable noun.
- The quantifier 'much' can only modify non-count (uncountable) mass nouns (e.g., 'how much sugar').
- To modify a plural countable noun, the quantifier 'many' must be used: 'How many spoonfuls of sugar...!'
- Therefore, 'Much' contains the grammatical error.

Why other options are incorrect:

- Option B:** 'Sugar' is a correctly used uncountable mass noun following the preposition 'of'.
- Option C:** 'Like' is the correct bare infinitive verb following the modal auxiliary 'would'.
- Option D:** 'In' is the correct preposition of place for a beverage cup.

Question #185 Key: (A)ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

The phrase "spiffed up" stands for:

CORE CONCEPT & DERIVATION

Idiomatic phrasal expressions convey figurative meanings distinct from their literal constituent words.

Formula / Rule / Reaction:'Spiff up' $\equiv$ To make oneself smartly dressed, spruce, or attractive**Solution:**

- The informal English idiom 'spiffed up' (or 'spiff up') means dressed smartly, tidily, elegantly, or in fashionable clothes for a special occasion.
- Thus, 'Dressed up' is the direct equivalent meaning.

Why other options are incorrect:

- Option B:** While 'cleaned up' relates to tidiness, 'spiffed up' specifically connotes dressing stylishly or improving one's personal appearance.
- Option C:** 'Upset' means emotionally distressed or agitated, which is unrelated.
- Option D:** 'Fade' means to lose color, brightness, or vitality over time.

Question #186 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

Read the following passage to answer the given question: In prolonged space flight, besides the...

CORE CONCEPT & DERIVATION

Contextual vocabulary comprehension relies on extracting semantic meaning from surrounding descriptive adjectives and noun associations.

Formula / Rule / Reaction:Rocky debris $\Rightarrow$ Broken solid geological fragments / scattered rock pieces**Solution:**

- In the context of spaceflight hazards alongside meteors, the phrase 'rocky debris' refers to scattered pieces, fragments, or remnants of rock floating in space that pose impact risks to a spacecraft.
- Therefore, 'Fragments' is the accurate contextual meaning.

Why other options are incorrect:

- Option B:** 'Decay' means organic decomposition or radioactive breakdown, not physical rocks in space.
- Option C:** 'Bacteria' refers to microscopic biological organisms, which is unrelated to rocky matter.
- Option D:** 'Alien life' refers to extraterrestrial organisms, which has no semantic connection to rock fragments.

Question #187 **Key: (C)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling*The money, property, etc that is used to start or operate a business is called?***CORE CONCEPT & DERIVATION**

Financial and commercial terminology defines business startup resources by specific investment categories.

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

- Capital investment (or business capital) refers to the financial funds, operational equipment, real estate, and resources contributed by owners or investors to establish and run an enterprise.

Why other options are incorrect:

- **Option A:** 'Cost' refers to the expenses incurred in manufacturing a good or rendering a service, rather than the initial pool of starting funds.
- **Option B:** An 'asset' is any individual resource of economic value owned by a business, whereas the total wealth used to start a business is capital investment.
- **Option D:** 'Fiscal status' describes the financial standing, creditworthiness, or budgetary position of an entity.

Question #188 **Key: (A)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling*The Queen of England bestowed a title upon the man who saved her life from a fatal accident. Wh...***CORE CONCEPT & DERIVATION**

Formal vocabulary in English includes elevated verbs for the official granting of honors and awards.

Formula / Rule / Reaction:

Bestow $\equiv$ To present as an honor, confer, grant, or award formally

Solution:

- The verb 'bestow' means to present an honor, right, or gift upon someone in a formal or ceremonial manner.
- 'Conferred' is an exact synonym meaning granted or awarded an academic degree, title, or honor.

Why other options are incorrect:

- **Option B:** 'Discard' means to get rid of or throw away something useless.
- **Option C:** 'Withdrawn' means retracted, taken back, or removed.
- **Option D:** 'Retailled' means sold in small quantities directly to the public for commercial profit.

Question #189 **Key: (D)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension*Correct the given sentence: I like cats, I hate dogs.***CORE CONCEPT & DERIVATION**

A comma splice error occurs when two independent clauses are joined with only a comma, requiring a coordinating conjunction or appropriate punctuation.

Formula / Rule / Reaction:

Independent Clause₁ + Coordinating Conjunction ('but') + Independent Clause₂

Solution:

- 'I like cats' and 'I hate dogs' are both independent clauses expressing contrasting sentiments.
- Joining them with only a comma creates a run-on sentence known as a comma splice.
- To correct this error and express contrast, the adversative coordinating conjunction 'but' must be added: 'I like cats but I hate dogs.'

Why other options are incorrect:

- **Option A:** A colon is used to introduce an explanation, list, or amplification, not to connect two contrasting assertions.
- **Option B:** Removing the comma produces a fused run-on sentence devoid of necessary boundary punctuation.
- **Option C:** Uses an apostrophe, which indicates possession or contraction and is completely ungrammatical here.

Question #190 **Key: (A)**ENGLISH
06. Punctuation, Capitalization & Reading Comprehension*Add suitable conjunction in the given sentence. Your ice cream will melt, you should eat it qui...***CORE CONCEPT & DERIVATION**

Illative coordinating conjunctions link an initial cause or condition to its logical result or recommended action.

Formula / Rule / Reaction:

Cause ('ice cream will melt') + 'so' + Effect / Action ('eat it quickly')

Solution:

- The clause 'Your ice cream will melt' presents a premise or reason.
- The following clause 'you should eat it quickly' represents the logical consequence and recommended action.
- The coordinating conjunction 'so' correctly establishes this cause-and-effect relationship.

Why other options are incorrect:

- **Option B:** 'However' is an adversative conjunctive adverb expressing contrast, which does not fit this cause-and-effect relationship.
- **Option C:** 'So that' expresses purpose or intent (e.g., 'I ran so that I wouldn't be late'), which creates nonsense here by implying the ice cream melts for the purpose of being eaten.
- **Option D:** 'However' cannot join two independent clauses with only a comma; doing so creates a run-on sentence.

Question #191 **Key: (A)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers

choose the correct option.

CORE CONCEPT & DERIVATION

Nouns designating paired-component tools exist only in plural form and require plural demonstratives and verbs.

Formula / Rule / Reaction:

Plural Demonstrative ('These') + Plural Noun ('scissors') + Plural Verb ('are')

Solution:

- The noun 'scissors' is plural-only (pluralia tantum) because the tool consists of two joined blades.
- It must be paired with the plural demonstrative determiner 'these' and the plural verb 'are'.
- Therefore, 'These scissors are very sharp' is the only grammatically correct sentence.

Why other options are incorrect:

- **Option B:** 'Scissor' in singular form is non-standard, and pairing it with 'this' and 'is' is incorrect.
- **Option C:** Combines the singular demonstrative 'this' and singular verb 'is' with the plural noun 'scissors'.
- **Option D:** Uses the incorrect non-standard singular form 'scissor' with the plural demonstrative 'these'.

Question #192 **Key: (C)**ENGLISH
05. Active-Passive Voice, Reported Speech & Syntax

Choose the sentence with correct word order.

CORE CONCEPT & DERIVATION

Canonical English syntax adheres to a strict Subject-Verb-Object-Adverbial (SVOA) constituent order.

Formula / Rule / Reaction:

Subject (Sue) + Verb (took) + Direct Object (the cover) + Prepositional Adverbial (from the window)

Solution:

- In a standard transitive English clause, the direct object must immediately follow the transitive verb without an intervening prepositional phrase.
- Subject: 'Sue'
- Transitive Verb: 'took'
- Direct Object: 'the cover'
- Adverbial of Place: 'from the window'
- This yields the grammatically correct sequence: 'Sue took the cover from the window.'

Why other options are incorrect:

- **Option A:** Inserts the prepositional phrase 'from the window' between the transitive verb 'took' and its direct object 'the cover'.
- **Option B:** Contains a corrupted, duplicated noun phrase that disrupts sentence structure.
- **Option D:** Places the direct object before the main verb, violating SVO order.

Question #193 **Key: (B)**ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

"To cut off the head" This idiom means:

CORE CONCEPT & DERIVATION

Etymological and lexical equivalents connect plain English idioms with precise single-word Latinate definitions.

Formula / Rule / Reaction:

'To cut off the head' ≡ Decapitate (from Latin: de- 'off' + caput 'head')

Solution:

- The verb 'decapitate' literally means to cut off or sever the head of a person or animal.
- Figuratively, it refers to neutralizing an organization by removing its leadership.

Why other options are incorrect:

- **Option A:** 'Defrock' means to officially strip a priest or minister of their clerical status.
- **Option C:** 'Impaled' means pierced through with a sharp, pointed stake or instrument.
- **Option D:** 'Urbanite' is a noun designating a person who lives in a city or urban environment.

Question #194 Key: (D)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

Choose the correct option. We must _____ the tickets for the movie in advance.

CORE CONCEPT & DERIVATION

Natural verb-noun collocations determine standard vocabulary selection in English.

Formula / Rule / Reaction:

Modal Auxiliary ('must') + Transitive Verb ('buy') + Object ('the tickets')

Solution:

- Acquiring movie theater admission passes prior to a screening requires the commercial transaction verb 'buy' (or 'purchase').
- 'Buy the tickets... in advance' is the natural, idiomatic English collocation.

Why other options are incorrect:

- **Option A:** 'Remove' means to take something away or eliminate it, which is nonsensical in this context.
- **Option B:** 'Take' implies grabbing or seizing tickets without purchasing them.
- **Option C:** 'Draw' means to sketch an illustration or pull something, which is incorrect here.

Question #195 Key: (D)LOGICAL REASONING
04. Argument Evaluation & Ethics

Read the paragraph carefully and answer the question given. "Over the past century the business..."

CORE CONCEPT & DERIVATION

Reading comprehension questions identify main conclusions that are directly substantiated by explicit text evidence.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- The passage explicitly credits the businessman with helping build civilization's great cities, providing luxuries, elevating standards of living, and expanding the industrial revolution globally.
- These achievements directly support the comprehensive conclusion that the businessman has contributed significantly to the growth and development of civilization.

Why other options are incorrect:

- **Option A:** The passage describes historical contributions, but makes no claim regarding legal or moral accountability to society.
- **Option B:** 'Seeding the industrial revolution' is used metaphorically; the passage makes no mention of supplying agricultural seeds.
- **Option C:** The passage portrays the businessman as a driving agent who seeded the industrial revolution, rather than merely a passive beneficiary.

Question #196 Key: (C)LOGICAL REASONING
11. Set Theory, Integer Bounds & Arithmetic

Some months have 31 days, how many have 28?

CORE CONCEPT & DERIVATION

Logical deduction questions require literal interpretation of numerical inclusion versus exclusivity.

Formula / Rule / Reaction:

Every calendar month has ≥ 28 days $\implies$ All 12 months include at least 28 days

Solution:

- The question asks: 'how many [months] have 28 [days]?'
- It does not ask which months have *only* or *exclusively* 28 days.
- Because all twelve months in the standard Gregorian calendar contain at least 28 days (February has 28 or 29 days, while the other eleven have 30 or 31 days), every single month contains a 28th day.
- Therefore, all 12 months have 28 days.

Why other options are incorrect:

- **Option A:** Incorrectly assumes the question asks for months that contain *only* 28 days.
- **Option B:** In a leap year every four years, February has 29 days, while still containing 28 days.
- **Option D:** 'None' is false because every month contains 28 days.

Question #197 Key: (D)LOGICAL REASONING
08. Letter Series & Coding-Decoding

Read the following and choose the correct answer. Mice are to cats as goats are to,

CORE CONCEPT & DERIVATION

Verbal analogies identify and mirror relational pairs based on ecological predator-prey relationships.

Formula / Rule / Reaction:

Prey : Predator $\implies$ Mice : Cats = Goats : Lions

Solution:

- In the initial pairing 'Mice are to cats', the relationship is prey to natural predator (domestic/wild cats hunt and consume mice).
- To complete the analogy 'goats are to...', we must find a natural apex predator that preys on goats.
- Lions are carnivores that hunt medium-sized ungulates such as goats.

Why other options are incorrect:

- **Option A:** Standard snakes do not routinely prey on adult goats as primary dietary targets.
- **Option B:** Hippopotamuses are herbivorous aquatic mammals that do not prey on goats.
- **Option C:** Horses are domestic herbivorous ungulates that share a non-predatory relationship with goats.

Question #198 Key: (A)LOGICAL REASONING
02. Cause and Effect Analysis

Read the following statements and identify the best cause and effect relation. (I) For the past...

CORE CONCEPT & DERIVATION

Cause-and-effect reasoning establishes logical priority where an administrative intervention produces an observable outcome.

Formula / Rule / Reaction:

$$\text{Cause (Action)} \rightarrow \text{Effect (Result)}$$

Solution:

- Statement II describes an action: the district administration organized training programs for volunteer literacy workers.
- Statement I describes the resulting positive outcome: the district's literacy rate has steadily risen over the past four years.
- The training of campaign volunteers improves their instructional efficacy, directly causing the rise in literacy.
- Therefore, Statement II is the cause and Statement I is its effect.

Why other options are incorrect:

- **Option B:** Reverses the relationship; a rising literacy rate does not cause the administration to establish training programs for volunteers.
- **Option C:** The statements do not represent independent effects of a third unmentioned common factor; they share a direct causal link.
- **Option D:** The two events are directly connected through the literacy campaign, rather than being independent occurrences.

Question #199 Key: (A)LOGICAL REASONING
08. Letter Series & Coding-Decoding

Observe and the pattern and select the next term in the sequence: P5QR, P4QS, P3QT, _____, P1QV

CORE CONCEPT & DERIVATION

Alphanumeric sequence patterns are solved by analyzing the independent progressions of numbers and letters at each positional index.

Formula / Rule / Reaction:

$$\text{Pattern: } P + [n - 1] + Q + [\text{Letter} + 1]$$

Solution:

- First letter: Fixed as 'P' throughout.
- Number: Decreases by 1 in each successive term: $5 \rightarrow 4 \rightarrow 3 \rightarrow 2 \rightarrow 1$. Thus, the missing term must have the number 2.
- Third letter: Fixed as 'Q' throughout.
- Fourth letter: Advances forward by 1 letter alphabetically in each term: $R \rightarrow S \rightarrow T \rightarrow U \rightarrow V$. Thus, the missing term must have the letter U.
- Combining these components gives: **P2QU**.

Why other options are incorrect:

- **Option B:** Relocates the number and includes an extra digit, breaking the positional sequence.
- **Option C:** Adds an extraneous letter 'Y' to the end of the four-character pattern.
- **Option D:** Omits the required number 2 and rearranges the alphanumeric order.

Question #200 **Key: (D)**LOGICAL REASONING
03. Courses of Action & Decision-Making

Statement: Due to increasing pollution, the government bans to use of all single-use plastic pr...

CORE CONCEPT & DERIVATION

A course of action is logically valid if it represents a practical, constructive measure that addresses the root problem or facilitates the implementation of a policy.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Course of Action I: Launching an awareness campaign educates the public and shifts consumer behavior toward eco-friendly alternatives, ensuring smooth public compliance with the plastic ban. Hence, I follows.
- Course of Action II: Providing subsidies to manufacturers of eco-friendly products increases the supply and lowers the cost of alternatives, preventing shortages and economic disruption following the ban. Hence, II follows.
- Because both actions are constructive, feasible, and directly support the policy objective, both I and II follow.

Why other options are incorrect:

- **Option A:** Fails to recognize that industrial subsidies (Action II) are essential to ensure adequate market supply of alternatives.
- **Option B:** Fails to recognize that public awareness (Action I) is necessary to build consumer acceptance and compliance.
- **Option C:** Incorrectly rejects two logical, effective policy measures.