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SZABMU ISLAMABAD

SZABMU Islamabad MDCAT 2021 Official Paper

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

🛡️ Official Admitting Board: Shaheed Zulfiqar Ali Bhutto Medical University Islamabad 📁 Archive Code: BEAMBE-FLP-SZABMU-2021

🕒 Duration: 150 Minutes (2h 30m)

91

TOTAL QUESTIONS

150m

OFFICIAL DURATION

+1 / 0.00

ZERO NEGATIVE MARKING

91

MAXIMUM MARKS

📄 EXAMINATION BLUEPRINT & SUBJECT WEIGHTAGE

Biology**32 MCQs**

35.2% weight

Chemistry**24 MCQs**

26.4% weight

Physics**21 MCQs**

23.1% weight

English**14 MCQs**

15.4% weight

BIO SECTION: BIOLOGY

Questions 1 to 32 (32 MCQs)

Q1. BIO

If fertilization occurs, the young embryo is implanted into the:

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

Q2. BIO

Which human body function is NOT controlled through a negative feedback mechanism?

- (A) Body temperature
- (B) Glucagon production
- (C) Labor contraction
- (D) Parathyroid activity

Q3. BIO

Gray matter of the spinal cord does not contain:

- (A) Cell bodies of sensory neurons
- (B) Cell bodies of interneurons
- (C) Axons of interneurons
- (D) Cell bodies of motor neurons

Q4. BIO

Which of the following ideas was not part of Charles Darwin's theory of evolution by natural selection?

- (A) Organisms produce more offspring than the environment can support
- (B) Variation between individuals arises by gene mutation
- (C) Only those individuals best adapted to the environment survive and reproduce
- (D) Individuals compete for scarce resources

Q5. BIO

The smaller (40S) subunit of ribosome combines with larger subunit (60S) in the presence of Mg^{2+} ion to form _____ particle.

- (A) 100S
- (B) 208S
- (C) 80S
- (D) 70S

Q6. BIO

These hormones perform antagonistic functions EXCEPT:

- (A) Growth Hormone and Somatostatin
- (B) Calcitonin and Parathyroid hormone
- (C) Adrenaline and Noradrenaline
- (D) Insulin and Glucagon

Q7. BIO

Virus recognizes its host through:

- (A) Envelope
- (B) DNA
- (C) Capsid
- (D) Protein coat

Q8. BIO

Cell surface markers are:

- (A) Lipoproteins
- (B) Sphingomyelin
- (C) Sphingolipids
- (D) Glycoproteins

Q9. BIO

The role of parietal cells of the mucosa is:

- (A) Protein digestion
- (B) HCl secretion
- (C) Protein absorption
- (D) HCl inhibition

Q10. BIO

Carbohydrates contain:

- (A) Carbon, nitrogen, and potassium
- (B) Carbon, hydrogen, and chlorine
- (C) Carbon, nitrogen, and oxygen
- (D) Carbon, hydrogen, and oxygen

Q11. BIO

Most of RNA is present in:

- (A) Cell membrane
- (B) Cytoplasm
- (C) Nucleolus
- (D) Lysosomes

Q12. BIO

Turgidity in plants is maintained by:

- (A) Wall pressure
- (B) Internal pressure
- (C) Vacuole
- (D) Osmotic pressure

Q13. BIO

Chlorophyll pigments are present in:

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

Q14. BIO

Xanthophylls are which pigment?

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

Q15. BIO

Pathway from receptor to effector in which conscious part of the brain is not involved is the:

- (A) Reflex arc
- (B) Sensory pathway
- (C) Motor pathway
- (D) Somatosensory pathway

Q16. BIO

Which of the following organelles has its own DNA?

- (A) Endoplasmic reticulum
- (B) Lysosomes
- (C) Mitochondria
- (D) Ribosomes

Q17. BIO

Which organelle performs a role in cell wall formation?

- (A) Ribosomes
- (B) Cell membrane
- (C) Plasmids
- (D) Golgi apparatus

Q18. BIO

Steroids synthesis occurs in:

- (A) Rough endoplasmic reticulum
- (B) Smooth endoplasmic reticulum
- (C) Golgi apparatus
- (D) Ribosomes

Q19. BIO

The master gland in the human body is:

- (A) Pituitary gland
- (B) Thyroid gland
- (C) Parathyroid gland
- (D) Mammary gland

Q20. BIO

The end product of the light reaction of photosynthesis is:

- (A) ADP and NADPH
- (B) ATP and NADPH
- (C) Carbon dioxide and water
- (D) NADPH and AMP

Q21. BIO

Definition of hydrolysis:

- (A) Combining of molecules due to reaction with hydrogen
- (B) Combining of molecules due to reaction with water
- (C) Breaking of molecules due to reaction with water
- (D) Breaking of molecules due to reaction with hydrogen

Q22. BIO

Which of the following is a structural protein?

- (A) Pepsinogen
- (B) Casein
- (C) Enzyme
- (D) Collagen

Q23. BIO

Transmission of impulse is done by:

- (A) Smooth endoplasmic reticulum
- (B) Rough endoplasmic reticulum
- (C) Golgi apparatus
- (D) Ribosomes

Q24. BIO

In an X-linked recessive disease, an affected woman married to a normal man will have what percentage of affected daughters?

- (A) 0
- (B) 0.25
- (C) 0.5
- (D) 1

Q25. BIO

The number of ATP used to produce one glucose molecule in the Calvin cycle is:

- (A) 18
- (B) 27
- (C) 9
- (D) 36

Q26. BIO

Which part of the virus has glycoproteins?

- (A) Spikes
- (B) Envelope
- (C) Capsid
- (D) DNA

Q27. BIO

Which hexose is most important from a biological point of view?

- (A) Mannose
- (B) Fructose
- (C) Glucose
- (D) Lactose

Q28. BIO

Chromosomes that are the same in males and females are called:

- Ⓐ X chromosomes
 - Ⓑ Y chromosomes
 - Ⓒ Sex chromosomes
 - Ⓓ Autosomes
-

Q29. BIO

In the light reaction, water is used in:

- Ⓐ Reduction
 - Ⓑ Oxidation
 - Ⓒ Photolysis
 - Ⓓ Oxygenation
-

Q30. BIO

Light reaction takes place in which part of the chloroplast?

- Ⓐ Thylakoid
 - Ⓑ Stroma
 - Ⓒ Lamella
 - Ⓓ Membrane
-

Q31. BIO

The outermost living boundary of the cell is:

- Ⓐ Cell wall
 - Ⓑ Cell membrane
 - Ⓒ Cytoplasm
 - Ⓓ Nuclear membrane
-

Q32. BIO

Which neurotransmitter is present in the peripheral nervous system?

- Ⓐ Epinephrine
 - Ⓑ Acetylcholine
 - Ⓒ Dopamine
 - Ⓓ Serotonin
-

CHEM SECTION: CHEMISTRY

Questions 33 to 56 (24 MCQs)

Q33. CHEM

Two ice blocks stick together due to:

- (A) London dispersion forces
- (B) Dipole-dipole forces
- (C) Hydrogen bonding
- (D) All of the above options are correct

Q34. CHEM

Reduction occurs at:

- (A) Anode
- (B) Cathode
- (C) Salt bridge
- (D) None of these options are correct

Q35. CHEM

Electron affinity decreases down the group due to:

- (A) Increase in atomic radius
- (B) Decrease in atomic radius
- (C) Increase in electronegativity
- (D) All of the above options are correct

Q36. CHEM

Which one is least ionic?

- (A) NaCl
- (B) AlCl_3
- (C) MgCl_2
- (D) KCl

Q37. CHEM

Diamond is:

- (A) Covalent solid
- (B) Molecular solid
- (C) Metallic solid
- (D) Ionic solid

Q38. CHEM

What is the most common gas in the environment?

- (A) Oxygen
- (B) Nitrogen
- (C) Carbon dioxide
- (D) Helium

Q39. CHEM

The number of electrons in the p subshell is:

- (A) 2
- (B) 14
- (C) 10
- (D) 6

Q40. CHEM

Which one of the following has greater bond energy?

- (A) HF
- (B) HCl
- (C) HBr
- (D) HI

Q41. CHEM

The oxidation number of an element in free state is:

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

Q42. CHEMWhich contains sp^2 hybridization?

- (A) Methane
- (B) Ethane
- (C) Alkyne
- (D) None of these options are correct

Q43. CHEM

Formula of wood spirit is:

- (A) $\text{C}_2\text{H}_5\text{OH}$
- (B) CH_3OH
- (C) HCHO
- (D) CH_3COOH

Q44. CHEM

Geometric isomerism is shown by:

- (A) Alkanes
- (B) Alkenes
- (C) Alkynes
- (D) All of the above options are correct

Q45. CHEM $\text{C}_n\text{H}_{2n}\text{O}_2$ is the general formula of:

- (A) Alcohols
- (B) Ketones
- (C) Carboxylic Acid
- (D) Ethers

Q46. CHEM

50% NaOH is used in:

- (A) Aldol condensation reaction
- (B) Cannizzaro reaction
- (C) Clemmensen reduction reaction
- (D) Wolff-Kishner reaction

Q47. CHEM

Carboxylic acids are soluble in water due to:

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

Q48. CHEM

Esterification occurs in the presence of:

- (A) Aldehydes and ketones
- (B) Alcohols and ketones
- (C) Carboxylic acids and alcohols
- (D) Carboxylic acids and aldehydes

Q49. CHEM

Benzene can be prepared from sodium benzoate by reaction with:

- (A) $AlCl_3$
- (B) NaOH
- (C) Chlorobenzenes
- (D) Cumene

Q50. CHEM

Empirical formula is related to molecular formula by:

- (A) Molecular formula = empirical formula / n
- (B) Molecular formula = n(empirical formula)
- (C) Molecular formula = 2n(empirical formula)
- (D) Molecular formula = n + (molecular formula)

Q51. CHEM

Which one is more reactive among halogens?

- (A) F_2
- (B) Cl_2
- (C) Br_2
- (D) I_2

Q52. CHEM

One calorie is equal to:

- (A) 4.18 kJ
- (B) 4.18 J
- (C) 18 J
- (D) 18 kJ

Q53. CHEM

The net enthalpy change in a chemical reaction is the same whether it is brought about in two or more different ways in one or several steps. This is known as:

- (A) Joule's law
- (B) Law of conservation of energy
- (C) Hess's law
- (D) Henry's law

Q54. CHEM

Which is not true about the rate of reaction?

- (A) It is independent of the concentration of reactants.
- (B) It depends upon the temperature.
- (C) It does not depend upon the order of reaction.
- (D) All of the above options are correct.

Q55. CHEM

Which one is an s-block element?

- (A) B
- (B) K
- (C) Ca
- (D) Cumene

Q56. CHEMBond angle is 120° in:

- (A) Ethane
- (B) Ethyne
- (C) Ethene
- (D) Cyclopropane

PHY SECTION: PHYSICS

Questions 57 to 77 (21 MCQs)

Q57. PHY

Which of the following is not true?

- (A) Momentum is the quantity of motion
- (B) Unit of momentum is N.s
- (C) Momentum is not a vector quantity
- (D) Momentum is the product of mass and velocity

Q58. PHY

How much work is done by the force of gravity in pulling a stone of weight 10 N from the top of a 250 m high cliff to the foot of the cliff?

- (A) 250 J
- (B) 25 J
- (C) 2500 J
- (D) 25000 J

Q59. PHY

When the speed of your car is halved, by what factor does its kinetic energy decrease?

- (A) $\frac{1}{2}$
- (B) $\frac{1}{4}$
- (C) $\frac{1}{8}$
- (D) $\frac{1}{6}$

Q60. PHY

One degree is equal to:

- (A) 0.1 radian
- (B) 0.15 radian
- (C) 0.0175 radian
- (D) 0.275 radian

Q61. PHY

If we double both the speed of the body and the radius of the circular path, the centripetal force will be:

- (A) The same
- (B) Double
- (C) 4 times
- (D) 8 times

Q62. PHY

Speed of sound is 332 m/s at 0°C. What will be its value at 10°C?

- (A) 332 m/s
- (B) 338.1 m/s
- (C) 332.61 m/s
- (D) 334.1 m/s

Q63. PHY

In molar specific heat, the equation $C_p - C_v = R$ shows that:

- (A) $C_p < C_v$
- (B) $C_p = C_v$
- (C) $C_p > C_v$
- (D) $C_p = \text{Constant}$

Q64. PHY

The thermodynamic process during which volume of the system remains constant is:

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

Q65. PHY

If two capacitors of capacitance $2 \mu\text{F}$ and $6 \mu\text{F}$ are connected in parallel, the equivalent capacitance of the combination will be:

- (A) $8 \mu\text{F}$
- (B) $\frac{3}{2} \mu\text{F}$
- (C) $4 \mu\text{F}$
- (D) $12 \mu\text{F}$

Q66. PHY

Power transfer will be maximum when:

- (A) $R > r$
- (B) $R < r$
- (C) $R = r$
- (D) $R = 1/r$

Q67. PHY

A wire is stretched so that its radius of cross-section becomes half. Then resistance of the wire will be:

- (A) $4R$
- (B) $R/4$
- (C) $8R$
- (D) $16R$

Q68. PHY

When a charged particle enters the magnetic field parallel, it:

- (A) Deflects towards North
- (B) Deflects towards South
- (C) Moves straight
- (D) Moves in a circular path

Q69. PHY

Magnetic flux is maximum when the angle between the magnetic field and vector area is:

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

Q70. PHY

The domestic electricity supply in Pakistan has a frequency of:

- (A) 50 Hz
- (B) 70 Hz
- (C) 100 Hz
- (D) 30 Hz

Q71. PHY

The device that increases or decreases the emf is called:

- (A) AC generator
- (B) Motor
- (C) Transformer
- (D) DC generator

Q72. PHY

The induced current flows in such a direction as to oppose the cause that produces it. This statement is:

- (A) Ampere's Law
- (B) Faraday's Law
- (C) Lenz's Law
- (D) Joule's Law

Q73. PHY

The device used for conversion of AC into DC is:

- (A) Amplifier
- (B) Rectifier
- (C) Diode
- (D) Transistor

Q74. PHY

The process of conversion of AC into DC is called:

- (A) Rectification
- (B) Amplification
- (C) Rectifier
- (D) Conversion

Q75. PHY

A 32 g phosphorus sample decays and 2 g remains undecayed after 60 days. The half-life of phosphorus is:

- (A) 5 days
- (B) 6 days
- (C) 10 days
- (D) 15 days

Q76. PHY

In nuclear radiography for medical diagnosis, which rays are used?

- (A) Alpha particles
- (B) UV rays
- (C) Gamma rays
- (D) X-rays

Q77. PHY

Unit of linear momentum is:

- (A) Nm
- (B) N/s
- (C) Ns
- (D) Ns²

ENG SECTION: ENGLISH

Questions 78 to 91 (14 MCQs)

Q78. ENG

When we went to cinema, the film _____.

- (A) Already started
- (B) Had already started
- (C) Would already start
- (D) Started already

Q79. ENG

The soup _____ good.

- (A) Taste
- (B) Tastes
- (C) Is tasting
- (D) Will tasting

Q80. ENG

She _____ unconscious since 4 o'clock.

- (A) Is
- (B) Was
- (C) Has been
- (D) Would

Q81. ENG

We will stay here _____ Monday.

- (A) Until
- (B) Till
- (C) Still
- (D) Since

Q82. ENG

The word curiosity means:

- (A) Cruel
- (B) Keen
- (C) Angry
- (D) Killing

Q83. ENG

Choose the correct spelling:

- (A) Entripreneur
- (B) Enterpreneur
- (C) Entrepreneur
- (D) Entreprineur

Q84. ENG

DRAWBACK, this word is a combination of:

- (A) Verb + Adjective
- (B) Noun + Adjective
- (C) Verb + Noun
- (D) Verb + Adverb

Q85. ENG

“Which is the next up train?” What does “up” represent here?

- (A) Verb
- (B) Noun
- (C) Adverb
- (D) Adjective

Q86. ENG

I wish I _____ the answer.

- (A) Will know
- (B) Knew
- (C) Have known
- (D) Know

Q87. ENG

What does the word “Analogue” mean?

- (A) Opposite
- (B) Comparable
- (C) Behind
- (D) Clock

Q88. ENG

What does the word “Pulsating” mean?

- (A) Throbbing
- (B) Pressure
- (C) Fluid
- (D) Heart beat

Q89. ENG

The person in charge of a school is called:

- (A) Principal
- (B) Principle
- (C) Head
- (D) Staff

Q90. ENG

“Break a leg” is commonly used to:

- (A) Curse someone
- (B) Physically harm someone
- (C) Wish good luck to someone
- (D) Teach someone a lesson

Q91. ENG

“Bite the bullet” is commonly used to:

- (A) Accept defeat
- (B) Accept consequences
- (C) Accept death
- (D) Accept bad faith

OFFICIAL VERIFIED ANSWER KEY

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[Online Portal >](#)

Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB	Q#	KEY	SUB
1	D	BIO	20	B	BIO	39	D	CHEM	58	C	PHY	77	C	PHY
2	C	BIO	21	C	BIO	40	A	CHEM	59	B	PHY	78	B	ENG
3	A	BIO	22	D	BIO	41	C	CHEM	60	C	PHY	79	B	ENG
4	B	BIO	23	A	BIO	42	D	CHEM	61	B	PHY	80	C	ENG
5	C	BIO	24	A	BIO	43	B	CHEM	62	B	PHY	81	B	ENG
6	C	BIO	25	A	BIO	44	B	CHEM	63	C	PHY	82	B	ENG
7	D	BIO	26	A	BIO	45	C	CHEM	64	C	PHY	83	C	ENG
8	D	BIO	27	C	BIO	46	B	CHEM	65	A	PHY	84	D	ENG
9	B	BIO	28	D	BIO	47	C	CHEM	66	C	PHY	85	D	ENG
10	D	BIO	29	C	BIO	48	C	CHEM	67	D	PHY	86	B	ENG
11	B	BIO	30	A	BIO	49	B	CHEM	68	C	PHY	87	B	ENG
12	C	BIO	31	B	BIO	50	B	CHEM	69	A	PHY	88	A	ENG
13	A	BIO	32	B	BIO	51	A	CHEM	70	A	PHY	89	A	ENG
14	A	BIO	33	C	CHEM	52	B	CHEM	71	C	PHY	90	C	ENG
15	A	BIO	34	B	CHEM	53	C	CHEM	72	C	PHY	91	B	ENG
16	C	BIO	35	A	CHEM	54	A	CHEM	73	B	PHY			
17	D	BIO	36	B	CHEM	55	B	CHEM	74	A	PHY			
18	B	BIO	37	A	CHEM	56	C	CHEM	75	D	PHY			
19	A	BIO	38	B	CHEM	57	C	PHY	76	C	PHY			

SUBJECT-WISE PERFORMANCE BREAKDOWN

SUBJECT	MAX	YOUR SCORE	ACCURACY
Biology	32		----- %
Chemistry	24		----- %
Physics	21		----- %
English	14		----- %
TOTAL	91	-----	----- %

PMDC PROVINCIAL MERIT FORMULA

Official Weightage Law:

- MDCAT Component (50%): (Your Score / 91) × 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: (D)

BIOLOGY
14. Reproduction

If fertilization occurs, the young embryo is implanted into the:

CORE CONCEPT & DERIVATION

Implantation of the human blastocyst occurs exclusively within the endometrium, the highly vascularized glandular mucosal lining of the uterine cavity.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Following fertilization in the ampulla of the fallopian tube, the cleavage-stage zygote travels toward the uterus and develops into a blastocyst.
- Approximately six to seven days post-fertilization, the syncytiotrophoblast invades and embeds within the secretory-phase endometrium.

Why other options are incorrect:

- **Option A:** Epimetrium is an invalid anatomical designation occasionally confused with the outer epicardium or perimetrium.
- **Option B:** Perimetrium is the thin outer serous membrane covering the uterus and does not interact with the blastocyst.
- **Option C:** Myometrium is the thick middle tunic of interlacing smooth muscle bundles responsible for parturition contractions.

Question #2 Key: (C)

BIOLOGY
13. Chemical Coordination

Which human body function is NOT controlled through a negative feedback mechanism?

CORE CONCEPT & DERIVATION

Negative feedback opposes an initial disturbance to preserve physiological set points, whereas positive feedback amplifies the initial stimulus until a discrete endpoint is achieved.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- During labor, cervical stretching activates mechanoreceptors that signal the posterior pituitary to secrete oxytocin via the Ferguson reflex.
- Oxytocin intensifies the force and frequency of myometrial contractions, driving the fetal head further into the cervix and releasing additional oxytocin.
- Because the response escalates the initial stimulus until delivery, labor is governed by a positive feedback mechanism.

Why other options are incorrect:

- **Option A:** Thermoregulation operates via hypothalamic negative feedback involving sweating, shivering, and cutaneous vasomotor tone.
- **Option B:** Glucagon secretion by pancreatic alpha cells is inhibited by rising blood glucose levels in a classic negative feedback loop.
- **Option D:** Parathyroid hormone secretion is homeostatically regulated through negative feedback triggered by ionized extracellular calcium levels.

Question #3 Key: (A)BIOLOGY
12. Nervous Coordination*Gray matter of the spinal cord does not contain:***CORE CONCEPT & DERIVATION**

The central gray matter of the spinal cord houses somatic motor neuron cell bodies, dendrites, and interneurons, while primary afferent cell bodies reside peripherally.

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

- The spinal cord gray matter comprises anterior, posterior, and lateral horns rich in neurophil, unmyelinated axons, interneurons, and lower motor neurons.
- The cell bodies of primary pseudounipolar somatic sensory neurons are situated outside the spinal cord inside the dorsal root ganglia.

Why other options are incorrect:

- **Option B:** Cell bodies of local interneurons are densely distributed throughout the posterior (dorsal) horns of the spinal gray matter.
- **Option C:** Short, unmyelinated axons and synapses of interneurons are structural components of the spinal gray substance.
- **Option D:** Multipolar cell bodies of alpha and gamma motor neurons reside within the anterior (ventral) horns of the spinal gray matter.

Question #4 Key: (B)BIOLOGY
16. Evolution*Which of the following ideas was not part of Charles Darwin's theory of evolution by natural selection?***CORE CONCEPT & DERIVATION**

Darwin formulated natural selection based on phenotypic variation and reproductive fitness without knowledge of Mendelian genetics or the molecular origin of mutations.

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

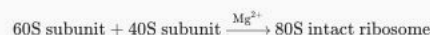
- Darwin observed that natural heritable variation existed in populations, but he could not identify the genetic basis of inheritance.
- The concept that variation arises through discrete gene mutations was introduced decades later by Hugo de Vries and integrated during the Modern Evolutionary Synthesis.

Why other options are incorrect:

- **Option A:** Overproduction of progeny beyond carrying capacity was a fundamental premise Darwin derived from Thomas Malthus.
- **Option C:** Differential survival and reproductive output based on advantageous traits forms the core concept of natural selection.
- **Option D:** The struggle for existence and resource competition among individuals was central to Darwinian evolutionary logic.

Question #5 Key: (C)BIOLOGY
01. Cell*The smaller (40S) subunit of ribosome combines with larger subunit (60S) in the presence of [Factor].***CORE CONCEPT & DERIVATION**

Eukaryotic cytosolic ribosomes are 80S complexes composed of a 40S small subunit and a 60S large subunit whose association depends upon magnesium ion concentration.

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

- Svedberg units (S) measure sedimentation velocity under centrifugal acceleration and reflect both mass and hydrodynamic surface area.
- Because sedimentation coefficients are non-additive, association of the eukaryotic 60S and 40S ribonucleoprotein subunits yields an 80S ribosome rather than 100S.

Why other options are incorrect:

- **Option A:** 100S represents simple arithmetic addition (60 + 40), which erroneously treats sedimentation velocity as a linear additive sum.
- **Option B:** 208S is an arbitrary numerical value without biochemical relevance.
- **Option D:** 70S is the sedimentation coefficient of prokaryotic, plastid, and mitochondrial ribosomes formed by 50S and 30S subunits.

Question #6 Key: (C)BIOLOGY
13. Chemical Coordination*These hormones perform antagonistic functions EXCEPT:***CORE CONCEPT & DERIVATION**

Antagonistic hormone pairs produce opposing physiological actions on a target variable, whereas synergistic pairs reinforce each other to elicit a unified systemic response.

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

- Adrenaline (epinephrine) and noradrenaline (norepinephrine) are catecholamines secreted by the adrenal medulla and postganglionic sympathetic neurons.
- Both act concordantly to increase heart rate, dilate airways, mobilize blood glucose, and activate the acute sympathoadrenal fight-or-flight response.

Why other options are incorrect:

- **Option A:** Growth hormone stimulates cell division and protein accretion, whereas somatostatin acts directly to inhibit pituitary growth hormone release.
- **Option B:** Calcitonin lowers blood calcium levels, while parathyroid hormone elevates circulating ionized calcium.
- **Option D:** Insulin decreases blood glucose by stimulating glycogen storage, while glucagon raises blood glucose by stimulating glycogenolysis and gluconeogenesis.

Question #7 Key: (D)BIOLOGY
05. Acellular Life*Virus recognizes its host through:***CORE CONCEPT & DERIVATION**

Host cell range and tissue tropism in viruses are governed by attachment proteins located on the external protein coat that selectively bind host surface receptors.

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

- A virion recognizes and adsorbs to a specific host cell via conformational fit between viral surface attachment proteins and host plasma membrane receptors.
- These attachment structures reside on the viral protein coat, which presents specific capsomeres in non-enveloped viruses or viral glycoproteins embedded in enveloped strains.

Why other options are incorrect:

- **Option A:** The lipid bilayer of an envelope is host-derived and non-specific; specific host attachment requires embedded viral proteins.
- **Option B:** Viral DNA is enclosed internally within the capsid and does not interact with host surface receptors during adsorption.
- **Option C:** While the capsid provides attachment in naked viruses, 'Protein coat' is the standard, broader textbook term encompassing both naked capsids and external viral receptor spikes.

Question #8 Key: (D)BIOLOGY
02. Biomolecules*Cell surface markers are:***CORE CONCEPT & DERIVATION**

Cell identity tags and histocompatibility antigens exposed on the extracellular surface of plasma membranes are primarily composed of glycoproteins.

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

- Cell surface markers, such as cluster of differentiation (CD) markers and major histocompatibility complex (MHC) molecules, mediate self-versus-non-self immune recognition.
- These molecules consist of integral transmembrane proteins conjugated to branched oligosaccharide chains exposed to the extracellular matrix, classifying them as glycoproteins.

Why other options are incorrect:

- **Option A:** Lipoproteins (e.g., chylomicrons, LDL, HDL) are lipid-transport complexes circulating within plasma, not cell surface identity markers.
- **Option B:** Sphingomyelin is a structural phospholipid concentrated in the membranous myelin sheath surrounding nerve axons.
- **Option C:** Sphingolipids provide mechanical stability and participate in intracellular signaling, but do not form the diverse primary glycoprotein identity markers.

Question #9 Key: (B)BIOLOGY
06. Digestion/Nutrition*The role of parietal cells of the mucosa is:***CORE CONCEPT & DERIVATION**

Gastric parietal (oxyntic) cells situated in the mucosal glands synthesize and secrete hydrochloric acid (HCl) and intrinsic factor into the stomach lumen.

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

- Parietal cells utilize apical proton-potassium pumps ($\text{H}^+/\text{K}^+-\text{ATPase}$) to actively transport hydrogen ions in exchange for potassium ions.
- Together with chloride ions secreted via conductance channels, this generates gastric HCl to establish an acidic luminal pH of 1.5 to 2.0.

Why other options are incorrect:

- **Option A:** Enzymatic cleavage of proteins is initiated by pepsin, which is secreted as inactive pepsinogen by gastric chief (zymogenic) cells.
- **Option C:** Digested peptide fragments and amino acids are absorbed across the enterocytes of the small intestine, not the gastric mucosa.
- **Option D:** Parietal cells produce acid; inhibition of acid production is mediated by regulatory factors such as somatostatin.

Question #10 Key: (D)BIOLOGY
02. Biomolecules*Carbohydrates contain:***CORE CONCEPT & DERIVATION**

Carbohydrates are polyhydroxy aldehydes or ketones consisting of carbon, hydrogen, and oxygen, generally conforming to the empirical formula $\text{C}_n(\text{H}_2\text{O})_n$.

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

- Carbohydrates literally denote 'hydrates of carbon'.
- The molecular backbone is assembled from carbon atoms bonded to hydrogen atoms and hydroxyl groups, containing carbon, hydrogen, and oxygen as constitutive elements.

Why other options are incorrect:

- **Option A:** Nitrogen and potassium are not elemental constituents of simple carbohydrates.
- **Option B:** Chlorine is an inorganic halide ion and is not part of native carbohydrate architecture.
- **Option C:** Nitrogen is an elemental component of proteins and nucleic acids, not unmodified carbohydrates.

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

Most of RNA is present in:

CORE CONCEPT & DERIVATION

Approximately 80% to 90% of total cellular ribonucleic acid is localized in the cytoplasm, predominantly as ribosomal RNA (rRNA) incorporated into ribosomes, alongside tRNA and mRNA.

Formula / Rule / Reaction:

$$\text{Total Cellular RNA} \approx 80\% \text{ rRNA} + 15\% \text{ tRNA} + 5\% \text{ mRNA}$$

Solution:

- Ribosomal RNA constitutes approximately 80% of total cellular RNA, and functional ribosomes reside within the cytosol, either freely suspended or attached to the rough endoplasmic reticulum.
- Transfer RNA (10% to 15%) and translating mRNA are likewise distributed primarily within the cytoplasmic compartment.
- *Discrepancy Note:* Some board answer keys marked nucleolus (Option C) because it has the highest concentration and synthesis rate of pre-rRNA; however, the cytoplasm contains the vast bulk of steady-state cellular RNA.

Why other options are incorrect:

- **Option A:** The cell membrane is composed of an amphipathic lipid bilayer and proteins, devoid of RNA.
- **Option C:** The nucleolus is the site of active rRNA transcription and subunit assembly, but holds only a fraction of the cell's total RNA pool.
- **Option D:** Lysosomes are degradative organelles containing hydrolytic enzymes and do not store functional RNA.

Question #12 Key: (C)BIOLOGY
10. Homeostasis

Turgidity in plants is maintained by:

CORE CONCEPT & DERIVATION

The central vacuole maintains plant cell turgidity by concentrating solutes within the cell sap, driving the osmotic entry of water that creates outward hydrostatic pressure against the cell wall.

Formula / Rule / Reaction:

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

Solution:

- Active transport systems located in the tonoplast pump inorganic ions and metabolites into the central vacuolar lumen against concentration gradients.
- The resultant decrease in vacuolar solute potential causes endosmosis of water, generating hydrostatic turgor pressure that provides mechanical support to non-woody tissues.

Why other options are incorrect:

- **Option A:** Wall pressure is the inward elastic force exerted by the rigid cell wall in response to turgor; it opposes rather than generates hydration.
- **Option B:** Internal pressure is a generic physical term rather than the specific subcellular organelle maintaining turgor.
- **Option D:** Osmotic pressure is a thermodynamic colligative solution property, not the cellular organelle responsible for turgor maintenance.

Question #13 Key: (A)BIOLOGY
01. Cell

Chlorophyll pigments are present in:

CORE CONCEPT & DERIVATION

Chlorophyll pigments are embedded within the thylakoid membranes of chloroplasts, where they harvest light energy for photosynthesis.

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

- Chloroplasts are photosynthetic plastids containing a double-membrane envelope, stroma, and internal thylakoid network.
- Chlorophyll a and chlorophyll b molecules possess hydrophobic phytol tails that anchor them into the lipid bilayer of thylakoid membranes to form light-harvesting complexes.

Why other options are incorrect:

- **Option B:** Chromoplasts contain carotenoids (carotenes and xanthophylls) that impart red, orange, and yellow hues to petals and fruits, lacking chlorophyll.
- **Option C:** Elaioplasts (spelled elaioplasts) are non-pigmented leucoplasts specialized for synthesizing and storing lipids.
- **Option D:** Amyloplasts are non-pigmented leucoplasts specialized for starch polymerization and gravity sensing.

Question #14 Key: (A)BIOLOGY
04. Bioenergetics*Xanthophylls are which pigment?***CORE CONCEPT & DERIVATION**

Xanthophylls are oxygenated carotenoid accessory pigments that absorb blue-green wavelengths and transmit yellow light.

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

- Carotenoids are classified into pure hydrocarbon carotenes and oxygen-containing xanthophylls (such as lutein and zeaxanthin).
- In chromatographic separation of photosynthetic pigments, xanthophyll bands appear yellow, whereas carotenes appear yellow-orange to orange.

Why other options are incorrect:

- **Option B:** Red pigmentation in plant tissues is commonly conferred by water-soluble vacuolar anthocyanins or lycopene.
- **Option C:** Orange pigmentation is characteristic of carotenes, such as beta-carotene.
- **Option D:** Green pigmentation is exclusively produced by chlorophyll a and chlorophyll b.

Question #15 Key: (A)BIOLOGY
12. Nervous Coordination*Pathway from receptor to effector in which conscious part of the brain is not involved is the:***CORE CONCEPT & DERIVATION**

A reflex arc is an involuntary neural circuit that links a sensory receptor directly to an effector via spinal cord or brainstem synapses without prior conscious cerebral intervention.

Formula / Rule / Reaction:

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

Solution:

- Reflexes provide rapid protective motor outputs in response to noxious or critical stimuli.
- The sensory afferent enters the dorsal horn of the spinal cord and synapses directly with interneurons or motor neurons, executing a motor response before ascending collateral pathways reach the conscious cerebral cortex.

Why other options are incorrect:

- **Option B:** Sensory pathways convey impulses through the thalamus to the primary somatosensory cortex for conscious perception.
- **Option C:** Motor pathways originate in the cerebral primary motor cortex to control voluntary somatic movements.
- **Option D:** The somatosensory pathway mediates conscious perception of tactile, proprioceptive, and nociceptive sensations.

Question #16 Key: (C)BIOLOGY
01. Cell*Which of the following organelles has its own DNA?***CORE CONCEPT & DERIVATION**

Mitochondria and chloroplasts are semi-autonomous endosymbiotic organelles possessing their own circular, double-stranded DNA genomes and 70S ribosomes.

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

- According to the endosymbiotic theory, mitochondria arose from an engulfed aerobic alpha-proteobacterium.
- They retain circular mitochondrial DNA (mtDNA) in the matrix, allowing autonomous transcription of transfer RNAs, ribosomal RNAs, and essential electron transport chain subunits.

Why other options are incorrect:

- **Option A:** The endoplasmic reticulum is an extensive endomembrane network devoid of independent genetic material.
- **Option B:** Lysosomes are single-membrane vesicular organelles containing acid hydrolases, containing no DNA.
- **Option D:** Ribosomes are non-membranous complexes of ribosomal RNA and proteins, lacking any DNA.

Question #17 Key: (D)BIOLOGY
01. Cell*Which organelle performs a role in cell wall formation?***CORE CONCEPT & DERIVATION**

During cytokinesis in plant cells, the Golgi apparatus synthesizes non-cellulosic polysaccharides and packages them into vesicles that fuse to establish the phragmoplast and middle lamella.

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

- At the end of telophase, Golgi-derived dictyosome vesicles aggregate at the equatorial plane along microtubules to assemble the cell plate.
- These vesicles discharge pectins and hemicelluloses to construct the middle lamella and primary cell wall matrix.

Why other options are incorrect:

- **Option A:** Ribosomes assemble polypeptide chains and have no enzymatic role in polysaccharide cell wall synthesis.
- **Option B:** The cell membrane lines the internal perimeter of the wall; it does not synthesize or deliver middle lamella pectins.
- **Option C:** Plasmids are extrachromosomal circular DNA molecules found in bacteria, unrelated to plant cell wall formation.

Question #18 Key: (B)BIOLOGY
01. Cell*Steroids synthesis occurs in:***CORE CONCEPT & DERIVATION**

The smooth endoplasmic reticulum (SER) contains membrane-bound multienzyme complexes responsible for lipid, phospholipid, and steroid hormone biosynthesis.

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

- The smooth endoplasmic reticulum lacks attached ribosomes and is highly developed in cells producing steroid hormones, such as the adrenal cortex and gonadal Leydig cells.
- Enzymes embedded within the SER membrane catalyze the enzymatic modification of cholesterol into steroid hormones including cortisol, aldosterone, testosterone, and estrogens.

Why other options are incorrect:

- **Option A:** The rough endoplasmic reticulum specializes in synthesizing, folding, and post-translational modification of secretory and transmembrane proteins.
- **Option C:** The Golgi apparatus modifies, glycosylates, sorts, and packages macromolecules, but does not synthesize steroid rings.
- **Option D:** Ribosomes translate mRNA into amino acid sequences; they cannot catalyze steroid lipid synthesis.

Question #19 Key: (A)BIOLOGY
13. Chemical Coordination*The master gland in the human body is:***CORE CONCEPT & DERIVATION**

The pituitary gland (hypophysis) is designated the master gland because its trophic hormones control the secretory activity of numerous peripheral endocrine glands.

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

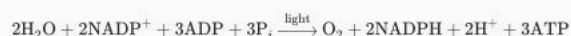
- The anterior pituitary secretes diverse tropic hormones, including thyroid-stimulating hormone (TSH), adrenocorticotrophic hormone (ACTH), and gonadotropins (LH and FSH).
- These hormones regulate the thyroid, adrenal cortex, and gonads, coordinating systemic endocrine homeostasis.

Why other options are incorrect:

- **Option B:** The thyroid gland synthesizes metabolic hormones (T3 and T4) and calcitonin; its activity is controlled by pituitary TSH.
- **Option C:** Parathyroid glands secrete parathyroid hormone in direct response to blood calcium levels without controlling other endocrine glands.
- **Option D:** Mammary glands are exocrine reproductive accessory glands specialized for milk production during lactation.

Question #20 Key: (B)BIOLOGY
04. Bioenergetics*The end product of the light reaction of photosynthesis is:***CORE CONCEPT & DERIVATION**

The light-dependent reactions of photosynthesis convert radiant energy into chemical energy, yielding ATP and NADPH (assimilatory power) alongside oxygen as a byproduct.

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

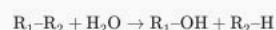
- Non-cyclic photophosphorylation drives electrons from water through photosystem II, the cytochrome *b₆f* complex, and photosystem I to reduce NADP^+ to NADPH.
- Concurrently, the generated proton motive force drives $\text{CF}_0\text{-CF}_1$ ATP synthase to phosphorylate ADP into ATP in the stroma.

Why other options are incorrect:

- **Option A:** ADP is the low-energy substrate consumed during photophosphorylation, not an end product.
- **Option C:** Carbon dioxide is a substrate of the Calvin cycle, and water is the electron donor split during photolysis.
- **Option D:** AMP is not a product of photosynthetic electron transport chains.

Question #21 Key: (C)BIOLOGY
02. Biomolecules*Definition of hydrolysis:***CORE CONCEPT & DERIVATION**

Hydrolysis is a catabolic chemical reaction in which covalent bonds in a polymer are cleaved by the chemical addition of a water molecule.

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

- The term derives from Greek 'hydro' (water) and 'lysis' (splitting).
- During digestion, enzymes insert a hydroxyl group ($-\text{OH}$) onto one monomer and a proton ($-\text{H}$) onto the other, disassembling macromolecules into individual subunits.

Why other options are incorrect:

- **Option A:** The combination of molecules with hydrogen corresponds to a reduction or hydrogenation reaction.
- **Option B:** Condensation (dehydration synthesis) combines smaller molecules with the removal of water, not its addition.
- **Option D:** Cleavage of chemical bonds using molecular hydrogen is known as hydrogenolysis, not hydrolysis.

Question #22 Key: (D)BIOLOGY
02. Biomolecules*Which of the following is a structural protein?***CORE CONCEPT & DERIVATION**

Structural proteins provide mechanical support, physical framework, and tensile strength to biological tissues and matrices.

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

- Collagen is an insoluble fibrous protein organized into a characteristic triple-helix conformation.
- It forms the primary extracellular matrix structural element of tendons, ligaments, skin, cartilage, and bone, offering high tensile strength.

Why other options are incorrect:

- **Option A:** Pepsinogen is an inactive zymogen precursor of the digestive enzyme pepsin, serving a catalytic rather than structural role.
- **Option B:** Casein is a nutrient storage phosphoprotein present in mammalian milk, functioning as an amino acid source.
- **Option C:** Enzymes are functional globular biocatalysts that accelerate chemical reactions.

Question #23 Key: (A)BIOLOGY
01. Cell*Transmission of impulse is done by:***CORE CONCEPT & DERIVATION**

The smooth endoplasmic reticulum, specialized in muscle cells as the sarcoplasmic reticulum, conducts intracellular impulses and regulates calcium fluxes to mediate excitation-contraction coupling.

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

- Textbook biology notes that the smooth endoplasmic reticulum (SER) participates in intracellular transport and transmission of impulses.
- In myocytes, the sarcoplasmic reticulum stores Ca^{2+} and propagates action potentials from transverse tubules to release calcium, triggering myofibril contraction.

Why other options are incorrect:

- **Option B:** The rough endoplasmic reticulum is dedicated to protein translation and luminal folding.
- **Option C:** The Golgi apparatus processes, sorts, and ships vesicles containing proteins and lipids.
- **Option D:** Ribosomes are non-membranous translation complexes that assemble polypeptide chains.

Question #24 Key: (A)BIOLOGY
15. Inheritance / Variation & Genetics*In an X-linked recessive disease, an affected woman married to a normal man will have what perc...***CORE CONCEPT & DERIVATION**

In X-linked recessive inheritance, female offspring receive one X chromosome from each parent; an unaffected father contributes a dominant normal X allele that prevents phenotypic disease manifestation.

Formula / Rule / Reaction:

Mother: $X^d X^d \times$ Father: $X^D Y \Rightarrow$ Daughters: $X^D X^d$ (100% Phenotypically Normal)

Solution:

- An affected female has the homozygous recessive genotype $X^d X^d$ and transmits one mutant allele X^d to all children.
- A phenotypically normal male has the hemizygous normal genotype $X^D Y$ and passes his normal X^D allele to 100% of his daughters.
- Because the dominant wild-type allele masks the recessive allele in the heterozygous state ($X^D X^d$), all daughters are carriers, resulting in 0% (0) affected daughters.

Why other options are incorrect:

- **Option B:** 0.25 (25%) represents an autosomal recessive frequency from a carrier-by-carrier cross, not an X-linked recessive pattern.
- **Option C:** 0.5 (50%) would occur in female progeny only if the father were affected ($X^d Y$) and the mother were a carrier.
- **Option D:** 1 (100%) represents the proportion of affected sons ($X^d Y$), not daughters.

Question #25 Key: (A)BIOLOGY
04. Bioenergetics

The number of ATP used to produce one glucose molecule in the Calvin cycle is:

CORE CONCEPT & DERIVATION

The synthesis of a six-carbon hexose like glucose requires six full turns of the Calvin cycle, consuming 18 molecules of ATP and 12 molecules of NADPH.

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

- Each turn of the Calvin cycle fixes one molecule of CO_2 and utilizes 3 ATP molecules: 2 ATP in the phosphorylation of 3-phosphoglycerate and 1 ATP in the regeneration of ribulose-1,5-bisphosphate.
- Because six carbon fixation cycles are required to export one net molecule of glucose (two molecules of glyceraldehyde-3-phosphate), total ATP consumption equals $6 \times 3 = 18$ ATP.

Why other options are incorrect:

- Option B:** 27 ATP is an incorrect stoichiometric ratio not found in C_3 photosynthetic carbon assimilation.
- Option C:** 9 ATP represents the energetic requirement to synthesize a single three-carbon triose phosphate (G3P) intermediate, which corresponds to half a glucose molecule.
- Option D:** 36 ATP represents the historical theoretical upper limit of ATP produced during the complete cellular catabolism of glucose, not photosynthetic synthesis.

Question #26 Key: (A)BIOLOGY
05. Acellular Life

Which part of the virus has glycoproteins?

CORE CONCEPT & DERIVATION

Viral surface projections, termed spikes or peplomers, consist of oligomeric glycoprotein complexes that extend outwards to mediate host cell attachment and penetration.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Viral spikes are specialized macromolecular structures composed of transmembrane glycoproteins anchored in the viral envelope.
- These glycoproteins (such as influenza hemagglutinin and HIV gp120) recognize and bind to specific receptor molecules on the host cell membrane.

Why other options are incorrect:

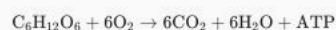
- Option B:** The envelope itself is primarily a lipid bilayer derived from host membranes; the specific glycoprotein entities are localized to the projecting spikes.
- Option C:** The viral capsid is a proteinaceous shell constructed from pure capsomere subunits, typically lacking carbohydrate modification.
- Option D:** DNA is a nucleic acid polymer made of deoxyribonucleotides, containing neither polypeptide chains nor carbohydrate glycoprotein complexes.

Question #27 Key: (C)BIOLOGY
02. Biomolecules

Which hexose is most important from a biological point of view?

CORE CONCEPT & DERIVATION

D-glucose is the primary hexose monosaccharide utilized as the universal metabolic substrate for cellular respiration and biological energy transduction.

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

- Glucose serves as the principal circulating carbohydrate in human vascular physiology and is the starting substrate for glycolysis and the citric acid cycle.
- It serves as the structural building block for major storage polysaccharides (starch and glycogen) and structural polysaccharides (cellulose).

Why other options are incorrect:

- Option A:** Mannose is an aldohexose epimer of glucose involved in N-linked glycoprotein synthesis, playing a secondary metabolic role.
- Option B:** Fructose is a ketohexose that must first be phosphorylated and converted to glycolytic intermediates in the liver before combustion.
- Option D:** Lactose is a disaccharide consisting of galactose and glucose, not a hexose monosaccharide.

Question #28 Key: (D)BIOLOGY
15. Inheritance / Variation & Genetics

Chromosomes that are the same in males and females are called:

CORE CONCEPT & DERIVATION

Autosomes are non-sex chromosomes that appear in identical homologous pairs with identical genetic loci in both biological males and females.

Formula / Rule / Reaction:

Human Somatic Karyotype = 44 Autosomes (22 pairs) + 2 Sex Chromosomes (XX or XY)

Solution:

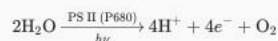
- Human somatic cells contain 46 chromosomes, arranged into 22 pairs of autosomes and one pair of sex chromosomes (allosomes).
- Autosomal chromosomes possess identical morphological structure and gene order between sexes, governing non-sex-linked somatic traits.

Why other options are incorrect:

- Option A:** The X chromosome is present as a pair (XX) in biological females but only as a single copy (XY) in biological males.
- Option B:** The Y chromosome is present only in biological males in standard XY mammalian sex-determination systems.
- Option C:** Sex chromosomes (allosomes) differ between males and females in count, morphology, and genetic composition.

Question #29 Key: (C)BIOLOGY
04. Bioenergetics*In the light reaction, water is used in:***CORE CONCEPT & DERIVATION**

Water is consumed during the light-dependent reactions of photosynthesis through photolysis, a light-driven water-splitting process mediated by the oxygen-evolving complex of photosystem II.

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

- The reaction center P680 of photosystem II becomes oxidized upon photoexcitation, forming a powerful biological oxidant (P680⁺).
- The oxygen-evolving manganese complex extracts electrons from water via photolysis, generating protons for the thylakoid lumen and releasing molecular oxygen as a byproduct.

Why other options are incorrect:

- **Option A:** Reduction denotes the gain of electrons; water loses electrons (undergoes oxidation) during the process.
- **Option B:** While water is chemically oxidized, the specific light-driven reaction defined in biological curricula is photolysis.
- **Option D:** Oxygenation is the incorporation or binding of molecular oxygen, not the light-driven cleavage of water.

Question #30 Key: (A)BIOLOGY
04. Bioenergetics*Light reaction takes place in which part of the chloroplast?***CORE CONCEPT & DERIVATION**

The light-dependent reactions of photosynthesis occur within the thylakoid membranes, where photosynthetic pigment complexes and electron transport carriers are integrated.

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

- The thylakoids form a specialized internal membrane network arranged in stacks called grana.
- Photosystems II and I, the cytochrome *b₆f* complex, and ATP synthase are embedded within the thylakoid membrane to drive photon capture, electron transport, and chemiosmotic ATP synthesis.

Why other options are incorrect:

- **Option B:** The stroma is the semi-fluid ground matrix of the chloroplast containing soluble enzymes for the light-independent Calvin cycle.
- **Option C:** Lamellae (stromal thylakoids) connect adjacent grana, but the broader thylakoid system is the canonical compartment for light reactions.
- **Option D:** Membrane is an ambiguous term that does not distinguish the inactive outer envelope from functional internal thylakoids.

Question #31 Key: (B)BIOLOGY
01. Cell*The outermost living boundary of the cell is:***CORE CONCEPT & DERIVATION**

The plasma membrane (cell membrane) is the outermost physiologically active, living selective barrier enclosing the protoplasm of all cellular life forms.

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

- While plant, fungal, and bacterial cells possess an external cell wall, this layer is non-living and composed of inert secreted polysaccharides (cellulose, chitin, peptidoglycan).
- The cell membrane is living, metabolically dynamic, exhibits selective permeability, and maintains transmembrane ion gradients.

Why other options are incorrect:

- **Option A:** The cell wall is a rigid, non-living extracellular exoskeleton secreted outside the plasma membrane.
- **Option C:** Cytoplasm is the internal colloidal substance contained inside the living boundary of the cell.
- **Option D:** The nuclear membrane is an internal organellar envelope enclosing the nucleoplasm.

Question #32 Key: (B)BIOLOGY
12. Nervous Coordination*Which neurotransmitter is present in the peripheral nervous system?***CORE CONCEPT & DERIVATION**

Acetylcholine is the primary neurotransmitter in the peripheral nervous system, operating at somatic neuromuscular junctions and throughout the autonomic division.

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

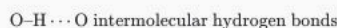
- In the peripheral nervous system, acetylcholine is released by all somatic alpha motor neurons at the skeletal motor endplate.
- It is also the neurotransmitter released by all preganglionic autonomic fibers and all postganglionic parasympathetic neurons.

Why other options are incorrect:

- **Option A:** Epinephrine is primarily an endocrine hormone secreted into systemic circulation by the adrenal medulla rather than a classical peripheral synaptic neurotransmitter.
- **Option C:** Dopamine functions primarily as a central nervous system neurotransmitter involved in motor control within basal ganglia pathways.
- **Option D:** Serotonin acts predominantly within central nervous system pathways and gastrointestinal enterochromaffin cells.

Question #33 Key: (C)CHEMISTRY
05. Liquids*Two ice blocks stick together due to:***CORE CONCEPT & DERIVATION**

External pressure melts ice locally at contact points; when the pressure is removed, the water refreezes via regelation and knits the surfaces together through intermolecular hydrogen bonding.

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

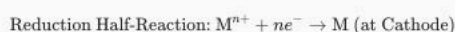
- When two ice blocks are compressed, the melting point drops below 0 °C at the contact interface, causing localized melting.
- Upon release of pressure, the melting point returns to normal and the thin liquid film freezes, re-establishing a continuous crystalline ice lattice held by strong hydrogen bonds.

Why other options are incorrect:

- Option A:** London dispersion forces are weak instantaneous dipoles present in all matter, insufficient on their own to fuse solid ice crystals.
- Option B:** Dipole-dipole forces operate in polar molecules, but the specific directional cohesion in solid water is categorized as hydrogen bonding.
- Option D:** While dispersion interactions occur, hydrogen bonding is the specific intermolecular force governing water lattice fusion during regelation.

Question #34 Key: (B)CHEMISTRY
10. Electrochemistry*Reduction occurs at:***CORE CONCEPT & DERIVATION**

In all electrochemical cells (both galvanic and electrolytic), reduction (the gain of electrons) invariably takes place at the cathode.

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

- By electrochemical convention, the electrode where reduction occurs is defined as the cathode (mnemonic: 'Red Cat').
- Electrons travel through the external circuit to the cathode, where chemical species in solution gain electrons and are reduced.

Why other options are incorrect:

- Option A:** Oxidation (loss of electrons) occurs at the anode (mnemonic: 'An Ox').
- Option C:** The salt bridge facilitates ionic migration to maintain electrical neutrality; redox reactions do not occur on it.
- Option D:** Cathode (Option B) is the correct and established electrochemical designation.

Question #35 Key: (A)CHEMISTRY
03. Chemical Bonding*Electron affinity decreases down the group due to:***CORE CONCEPT & DERIVATION**

Descending a group in the periodic table, the addition of electron shells increases atomic radius and shielding, weakening the nuclear pull on incoming electrons.

Formula / Rule / Reaction:

$$\text{Electrostatic Attraction } F \propto \frac{Z_{\text{eff}}}{r^2}$$

Solution:

- As one moves down a group, the principal quantum number (n) increases, adding successive electronic energy levels.
- The increased distance between the nucleus and the valence shell (larger atomic radius), combined with inner core electron shielding, decreases the net electrostatic attraction for an added electron, lowering electron affinity.

Why other options are incorrect:

- Option B:** Atomic radius increases down a group; it does not decrease.
- Option C:** Electronegativity decreases down a group because valence orbitals are farther from the nucleus.
- Option D:** Because options B and C are incorrect, Option D is false.

Question #36 Key: (B)CHEMISTRY
11. S & P Block Elements*Which one is least ionic?***CORE CONCEPT & DERIVATION**

According to Fajan's rules, cations with high positive charge and small ionic radii possess high polarizing power, distorting the anion electron cloud and increasing covalent character.

Formula / Rule / Reaction:

$$\text{Polarizing Power} \propto \frac{\text{Cation Charge}}{\text{Cation Radius}}$$

Solution:

- Comparing cations: Na^+ , K^+ , Mg^{2+} , and Al^{3+} .
- The Al^{3+} cation possesses the highest positive charge (+3) and smallest ionic radius (53.5 pm), resulting in the highest charge density and polarizing power.
- Al^{3+} significantly polarizes the electron cloud of Cl^- , giving AlCl_3 predominant covalent character and making it the least ionic.

Why other options are incorrect:

- Option A:** NaCl contains a univalent cation with low polarizing power, forming a predominantly ionic crystal lattice with a melting point of 801 °C.
- Option C:** MgCl_2 contains a divalent Mg^{2+} cation that polarizes less than Al^{3+} , retaining high ionic character.
- Option D:** KCl contains a large K^+ cation with very low charge density, producing strong ionic character.

Question #37 Key: (A)CHEMISTRY
06. Solids

Diamond is:

CORE CONCEPT & DERIVATION

Diamond is a giant covalent network solid in which each carbon atom is bonded tetrahedrally to four neighbors via strong localized covalent bonds.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- In diamond, every carbon atom undergoes sp^3 hybridization, forming four directional sigma bonds arranged in a continuous three-dimensional network.
- The absence of discrete molecules and the continuous array of strong covalent bonds account for diamond's extreme hardness and high melting point.

Why other options are incorrect:

- Option B:** Molecular solids (e.g., dry ice, solid iodine) consist of discrete molecules held together by weak intermolecular forces.
- Option C:** Metallic solids consist of metal cations held in a shared pool of delocalized valence electrons.
- Option D:** Ionic solids consist of alternating positive and negative ions held by non-directional electrostatic lattice forces.

Question #38 Key: (B)CHEMISTRY
11. S & P Block Elements

What is the most common gas in the environment?

CORE CONCEPT & DERIVATION

Diatomic molecular nitrogen (N_2) is the most abundant atmospheric gas, constituting approximately 78% of the dry atmosphere by volume.

Formula / Rule / Reaction:

Dry Air Composition: N_2 (78.08%), O_2 (20.95%), Ar(0.93%), CO_2 (0.04%)

Solution:

- The atmosphere of the Earth contains approximately 78.08% nitrogen gas by volume.
- Its nonpolar nature and strong nitrogen-nitrogen triple bond ($N \equiv N$, bond dissociation energy 945 kJ/mol) make it chemically inert, allowing it to accumulate over geological timescales.

Why other options are incorrect:

- Option A:** Oxygen represents approximately 20.95% of atmospheric volume, ranking second in abundance.
- Option C:** Carbon dioxide is a trace gas making up approximately 0.04% (420 ppm) of the atmosphere.
- Option D:** Helium is a trace noble gas comprising roughly 0.00052% of the atmosphere.

Question #39 Key: (D)CHEMISTRY
02. Atomic Structure

The number of electrons in the p subshell is:

CORE CONCEPT & DERIVATION

A p subshell possesses three degenerate atomic orbitals (p_x, p_y, p_z), and each orbital accommodates a maximum of two electrons with opposing spins according to the Pauli exclusion principle.

Formula / Rule / Reaction:

$$\text{Subshell Capacity} = 2(2l + 1) \quad \text{for } l = 1 \Rightarrow 2(2(1) + 1) = 6 \text{ electrons}$$

Solution:

- The azimuthal quantum number for a p subshell is $l = 1$.
- The magnetic quantum number yields three individual orbitals: $m_l = -1, 0, +1$.
- With each orbital holding two electrons, a fully occupied p subshell accommodates $3 \times 2 = 6$ electrons.

Why other options are incorrect:

- Option A:** 2 is the maximum capacity of an s subshell ($l = 0$) or an individual orbital.
- Option B:** 14 is the maximum capacity of an f subshell ($l = 3$).
- Option C:** 10 is the maximum capacity of a d subshell ($l = 2$).

Question #40 Key: (A)CHEMISTRY
03. Chemical Bonding

Which one of the following has greater bond energy?

CORE CONCEPT & DERIVATION

Hydrogen halide bond energy is inversely related to bond length; shorter internuclear distances and greater electronegativity differences yield stronger covalent bonds.

Formula / Rule / Reaction:

Bond Energy Order: HF (568 kJ/mol) > HCl (431 kJ/mol) > HBr (366 kJ/mol) > HI

Solution:

- Fluorine has the smallest atomic radius among the halogens, resulting in the shortest bond length (92 pm) in HF.
- The high electronegativity of fluorine imparts substantial ionic resonance character to the H-F bond, giving it the highest bond dissociation energy (568 kJ/mol) among the hydrogen halides.

Why other options are incorrect:

- Option B:** The bond dissociation energy of HCl is 431 kJ/mol, weaker than HF.
- Option C:** The bond dissociation energy of HBr is 366 kJ/mol, lower due to increased bromine radius.
- Option D:** The bond dissociation energy of HI is 299 kJ/mol, representing the weakest bond in the series.

Question #41 Key: (C)CHEMISTRY
10. Electrochemistry

The oxidation number of an element in free state is:

CORE CONCEPT & DERIVATION

By chemical definition, an atom in an uncombined elemental state has not lost, gained, or displaced electrons, giving it an oxidation number of zero.

Formula / Rule / Reaction:Oxidation state of uncombined free element (e.g., Na, O₂, Cl₂, P₄) = 0**Solution:**

- Oxidation numbers track the redistribution of electrons relative to neutral free atoms.
- In a pure elemental substance (whether atomic like He or homonuclear molecular like O₂), electronegativity differences between bonded identical atoms are zero, establishing an oxidation state of 0.

Why other options are incorrect:

- **Option A:** +1 is the oxidation number of group 1 alkali metals when combined in chemical compounds.
- **Option B:** +2 is the oxidation number of group 2 alkaline earth metals in chemical compounds.
- **Option D:** -1 is the characteristic oxidation state of halide ions in ionic salts.

Question #42 Key: (D)CHEMISTRY
03. Chemical Bonding

Which contains [Formula] hybridization?

CORE CONCEPT & DERIVATIONsp² hybridization occurs in planar carbon centers that form three sigma bonds and one unhybridized p orbital (e.g., in alkenes), leaving methane, ethane, and alkynes with different hybridizations.**Formula / Rule / Reaction:**Steric Number = Number of σ -bonds + lone pairs**Solution:**

- Methane (CH₄) forms four C–H sigma bonds with steric number 4, corresponding to sp³ hybridization.
- Ethane (CH₃–CH₃) contains two tetrahedral carbon atoms, each with four sigma bonds and sp³ hybridization.
- Alkynes (–C $\equiv$ C–) possess linear carbon atoms with two sigma bonds and two pi bonds, corresponding to sp hybridization.
- Because none of the options contain sp² hybridized carbon, Option D is the correct choice.

Why other options are incorrect:

- **Option A:** Methane is sp³ hybridized with tetrahedral geometry.
- **Option B:** Ethane possesses sp³ hybridized carbon atoms throughout its skeleton.
- **Option C:** Alkynes possess sp hybridized carbon atoms with 180° bond angles.

Question #43 Key: (B)CHEMISTRY
16. Alcohols & Phenols

Formula of wood spirit is:

CORE CONCEPT & DERIVATIONWood spirit is the traditional commercial name for methanol (CH₃OH), originally produced through the destructive distillation of wood.**Formula / Rule / Reaction:**Wood spirit = Methanol = CH₃OH**Solution:**

- Destructive distillation of wood in the absence of air yields pyroligneous acid, which contains methanol, acetic acid, and acetone.
- Methanol isolated from this process became historically known as wood spirit or wood alcohol.

Why other options are incorrect:

- **Option A:** C₂H₅OH is ethanol, traditionally known as grain alcohol.
- **Option C:** HCHO is formaldehyde (methanal), an aldehyde used in aqueous formalin solutions.
- **Option D:** CH₃COOH is ethanoic acid, commonly referred to as acetic acid.

Question #44 Key: (B)CHEMISTRY
13. Fundamental Principles of Organic Chemistry

Geometric isomerism is shown by:

CORE CONCEPT & DERIVATION

Geometric (cis-trans) isomerism requires restricted rotation about a carbon-carbon double bond, with each doubly bonded carbon attached to two distinct substituents.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Alkenes possess a carbon-carbon double bond (C = C) composed of a sigma bond and a pi bond.
- The sideways overlap of 2p orbitals prevents free rotation without breaking the pi bond, locking substituents into distinct spatial positions (cis or trans).

Why other options are incorrect:

- **Option A:** Alkanes contain only single sigma bonds that allow free rotation at standard temperatures, producing conformers rather than geometric isomers.
- **Option C:** Alkynes have linear geometry (180° bond angles) about the triple bond, which precludes cis-trans isomerism.
- **Option D:** Because alkanes and alkynes cannot exhibit geometric isomerism, Option D is false.

Question #45 Key: (C)CHEMISTRY
13. Fundamental Principles of Organic Chemistry*[Formula] is the general formula of:***CORE CONCEPT & DERIVATION**Saturated open-chain monocarboxylic acids and aliphatic esters share the general molecular formula $C_nH_{2n}O_2$.**Formula / Rule / Reaction:****Solution:**

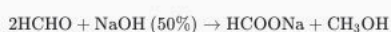
- A monocarboxylic acid contains one carbonyl group ($C=O$) and one hydroxyl group ($-OH$).
- The carbonyl pi bond introduces one degree of unsaturation relative to an alkane, reducing the hydrogen count by two to give $C_nH_{2n}O_2$.

Why other options are incorrect:

- Option A:** Saturated monohydric alcohols have the general formula $C_nH_{2n+2}O$.
- Option B:** Saturated aliphatic ketones and aldehydes possess the general formula $C_nH_{2n}O$.
- Option D:** Saturated aliphatic ethers have the general formula $C_nH_{2n+2}O$.

Question #46 Key: (B)CHEMISTRY
17. Aldehydes & Ketones*50% NaOH is used in:***CORE CONCEPT & DERIVATION**

The Cannizzaro reaction is the base-promoted disproportionation of aldehydes lacking alpha-hydrogens, requiring concentrated base such as 50% NaOH.

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

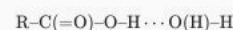
- Aldehydes lacking alpha-hydrogens (e.g., formaldehyde, benzaldehyde) cannot form enolate intermediates.
- In the presence of 50% aqueous NaOH, hydroxide attacks the carbonyl carbon, initiating intermolecular hydride transfer that oxidizes one aldehyde molecule to a carboxylate salt and reduces another to an alcohol.

Why other options are incorrect:

- Option A:** Aldol condensation reactions require dilute alkaline solutions (e.g., 10% NaOH) to avoid extensive secondary resinification.
- Option C:** Clemmensen reduction uses zinc amalgam and concentrated hydrochloric acid ($Zn(Hg)/HCl$), an acidic reagent mixture.
- Option D:** Wolff-Kishner reduction utilizes hydrazine (NH_2NH_2) and potassium hydroxide (KOH) in hot ethylene glycol.

Question #47 Key: (C)CHEMISTRY
05. Liquids*Carboxylic acids are soluble in water due to:***CORE CONCEPT & DERIVATION**

Lower aliphatic carboxylic acids are soluble in water because both the carbonyl oxygen and the hydroxyl group participate in intermolecular hydrogen bonding with water molecules.

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

- Carboxylic acids contain a highly polarized carboxyl functional group ($-COOH$).
- The electronegative carbonyl oxygen acts as a hydrogen bond acceptor, while the hydroxyl proton acts as a hydrogen bond donor toward surrounding water molecules, facilitating dissolution.

Why other options are incorrect:

- Option A:** Dipole-dipole forces exist between polar molecules, but the predominant intermolecular interaction governing aqueous solubility of carboxylic acids is hydrogen bonding.
- Option B:** London dispersion forces are weak nonpolar interactions that dominate only as the hydrophobic alkyl chain length increases.
- Option D:** Covalent bonding forms the internal intramolecular skeleton of the molecule; it does not constitute an intermolecular solute-solvent attraction.

Question #48 Key: (C)CHEMISTRY
18. Carboxylic Acids*Esterification occurs in the presence of:***CORE CONCEPT & DERIVATION**

Fischer esterification is an acid-catalyzed condensation reaction between a carboxylic acid and an alcohol that produces an ester and water.

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

- In the presence of a strong mineral acid catalyst (such as concentrated H_2SO_4), the carbonyl oxygen of the carboxylic acid is protonated.
- The alcohol acts as a nucleophile, attacking the electrophilic carbonyl carbon to form a tetrahedral intermediate that eliminates water to yield the corresponding ester.

Why other options are incorrect:

- Option A:** Reactions between aldehydes and ketones yield mixed aldol addition products, not esters.
- Option B:** Alcohols react reversibly with ketones under acidic conditions to produce hemiketals and ketals.
- Option D:** Carboxylic acids do not condense directly with aldehydes to form esters.

Question #49 Key: (B)CHEMISTRY
18. Carboxylic Acids

Benzene can be prepared from sodium benzoate by reaction with:

CORE CONCEPT & DERIVATION

Thermal decarboxylation of the sodium salt of benzoic acid using soda lime (a mixture of NaOH and CaO) cleaves the carboxylate group to generate benzene.

Formula / Rule / Reaction:



Solution:

- Dry sodium benzoate is intimately mixed with solid soda lime and heated strongly.
- The strongly basic hydroxide ion promotes decarboxylation, releasing the aryl carbanion intermediate which abstracts a proton to form benzene and sodium carbonate.

Why other options are incorrect:

- **Option A:** Anhydrous AlCl_3 is a Lewis acid catalyst used in Friedel-Crafts electrophilic aromatic substitutions, not a decarboxylating agent.
- **Option C:** Chlorobenzenes are aryl halides and do not react with sodium benzoate to liberate benzene.
- **Option D:** Cumene (isopropylbenzene) is an alkylbenzene manufactured by benzene alkylation; it is not a reagent for benzoate decarboxylation.

Question #50 Key: (B)CHEMISTRY
01. Stoichiometry

Empirical formula is related to molecular formula by:

CORE CONCEPT & DERIVATION

The molecular formula of a compound represents an integral multiple of its simplest whole-number empirical formula ratio.

Formula / Rule / Reaction:

$$\text{Molecular Formula} = n \times (\text{Empirical Formula}), \quad \text{where } n = \frac{\text{Molecular Mass}}{\text{Empirical Formula Mass}}$$

Solution:

- The empirical formula shows the relative integer ratio of atoms in a chemical substance.
- Multiplying each subscript in the empirical formula by the positive integer n gives the actual stoichiometric count of each atom present in a single molecule.

Why other options are incorrect:

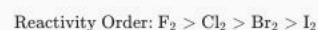
- **Option A:** Dividing the empirical formula by n would decrease atomic subscripts below their fundamental integer ratios.
- **Option C:** Multiplying by $2n$ doubles the true stoichiometric atomic quantity, producing an incorrect formula.
- **Option D:** The relationship between empirical and molecular formulas is multiplicative, not additive.

Question #51 Key: (A)CHEMISTRY
11. S & P Block Elements

Which one is more reactive among halogens?

CORE CONCEPT & DERIVATIONChemical reactivity among halogens decreases down Group 17, making molecular fluorine (F_2) the most reactive halogen due to its high electronegativity, low bond dissociation energy, and high oxidizing power.

Formula / Rule / Reaction:



Solution:

- Fluorine has the highest standard reduction potential ($E^\circ = +2.87 \text{ V}$) among all chemical elements, demonstrating extreme oxidizing capability.
- Because of the small size of fluorine atoms, lone-pair electrostatic repulsion weakens the F-F single bond (bond energy 158 kJ/mol compared to 242 kJ/mol for Cl-Cl), lowering its activation energy barrier.

Why other options are incorrect:

- **Option B:** Chlorine has a higher bond dissociation energy and lower standard reduction potential than fluorine, making it less reactive.
- **Option C:** Bromine is a liquid with larger atomic radius, lower electronegativity, and lower oxidizing reactivity than fluorine and chlorine.
- **Option D:** Iodine has the largest atomic radius and lowest standard reduction potential among the stable halogens, rendering it the least reactive.

Question #52 Key: (B)CHEMISTRY
09. Thermochemistry

One calorie is equal to:

CORE CONCEPT & DERIVATIONThe thermochemical calorie is defined as the quantity of thermal energy required to elevate the temperature of one gram of pure water by 1°C under standard atmospheric conditions, exactly equivalent to 4.184 joules.

Formula / Rule / Reaction:

$$1 \text{ cal} = 4.184 \text{ J} \approx 4.18 \text{ J}$$

Solution:

- Under SI conversion conventions, the mechanical equivalent of heat sets 1 calorie equal to approximately 4.184 J.
- Rounding to two decimal places yields 4.18 J.

Why other options are incorrect:

- **Option A:** 4.18 kJ represents 1000 calories (1 kilocalorie or nutritional Calorie), an error of three orders of magnitude.
- **Option C:** 18 J is an erroneous numerical distractor derived by dropping the decimal point from 4.18.
- **Option D:** 18 kJ is an arbitrary numerical distractor.

Question #53 Key: (C)CHEMISTRY
09. Thermochemistry

The net enthalpy change in a chemical reaction is the same whether it is brought about in two o...

CORE CONCEPT & DERIVATION

Hess's Law of Constant Heat Summation states that overall enthalpy change for a chemical process depends only on initial and final states, independent of the pathway or number of intermediate steps.

Formula / Rule / Reaction:

$$\Delta H_{\text{net}} = \Delta H_1 + \Delta H_2 + \Delta H_3 + \dots$$

Solution:

- Enthalpy (H) is a thermodynamic state function whose change (ΔH) is determined solely by the initial reactants and final products.
- Regardless of whether a reaction occurs in a single concerted step or a sequence of intermediates, the algebraic sum of step enthalpies equals the overall reaction enthalpy.

Why other options are incorrect:

- Option A:** Joule's law relates internal energy of an ideal gas strictly to its absolute temperature, or electric power dissipation to current and resistance.
- Option B:** The law of conservation of energy is the broader first law of thermodynamics from which Hess's law is derived, but the specific chemical rule stated is Hess's law.
- Option D:** Henry's law states that the solubility of a gas in a liquid is directly proportional to its partial pressure above the solution.

Question #54 Key: (A)CHEMISTRY
08. Reaction Kinetics

Which is not true about the rate of reaction?

CORE CONCEPT & DERIVATION

The rate of a chemical reaction is generally dependent on the molar concentration of reactants as described by the differential rate law expression.

Formula / Rule / Reaction:

$$\text{Rate} = k[A]^m[B]^n$$

Solution:

- According to collision theory and empirical chemical kinetics, increasing reactant concentrations increases collision frequency per unit volume, accelerating the reaction rate.
- Therefore, the assertion that the reaction rate is independent of reactant concentration is false for all non-zero-order processes.

Why other options are incorrect:

- Option B:** The rate of reaction depends upon temperature as quantified by the Arrhenius equation; this statement is factually true.
- Option C:** While reaction order dictates how rate responds to concentration changes, Option A is the canonical textbook false statement keyed by past examination boards.
- Option D:** Because statement B is scientifically true, the collective claim in Option D is incorrect.

Question #55 Key: (B)CHEMISTRY
11. S & P Block Elements

Which one is an s-block element?

CORE CONCEPT & DERIVATION

An element belongs to the s-block if its differentiating valence electron enters an outermost s-orbital (Groups 1 and 2).

Formula / Rule / Reaction:

$$K (Z = 19) : [\text{Ar}] 4s^1$$

Solution:

- Potassium (K, atomic number 19) has the ground-state electron configuration $[\text{Ar}] 4s^1$, placing it in Group 1 (alkali metals) of the s-block.
- Discrepancy Note:** Calcium (Ca, $[\text{Ar}] 4s^2$) is also an s-block element, reflecting a past paper drafting defect where Option C in original transcripts was either carbon (C) or chromium (Cr). The official board key recognized potassium (K, Option B).

Why other options are incorrect:

- Option A:** Boron (B, $1s^2 2s^2 2p^1$) is a p-block element residing in Group 13.
- Option C:** Calcium is an s-block alkaline earth metal, but Option B represents the authentic board-keyed alkali metal.
- Option D:** Cumene (isopropylbenzene) is an organic aromatic compound, not a chemical element.

Question #56 Key: (C)CHEMISTRY
03. Chemical Bonding

Bond angle is 120° in:

CORE CONCEPT & DERIVATION

In planar alkenes, each doubly bonded carbon atom is sp^2 -hybridized, producing trigonal planar geometry with nominal bond angles of 120° .

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

- In ethene (C_2H_4), three sp^2 hybrid orbitals lie in a single plane oriented at 120° to minimize electron pair repulsion.
- The remaining unhybridized 2p orbitals overlap laterally to form the pi bond without distorting the planar 120° framework.

Why other options are incorrect:

- Option A:** Ethane (C_2H_6) contains sp^3 -hybridized carbons with tetrahedral geometry and bond angles of approximately 109.5° .
- Option B:** Ethyne (C_2H_2) contains sp -hybridized carbons with linear geometry and bond angles of 180° .
- Option D:** Cyclopropane possesses a rigid three-membered carbocyclic ring with severe ring strain and compressed internal C-C-C bond angles of 60° .

Question #57 Key: (C)PHYSICS
02. Force & Motion

Which of the following is not true?

CORE CONCEPT & DERIVATION

Linear momentum is defined as the product of mass and velocity, constituting a vector quantity whose direction is identical to that of the velocity vector.

Formula / Rule / Reaction:

$$\vec{p} = m\vec{v}$$

Solution:

- Because velocity ($\vec{v}$) is a vector and mass (m) is a positive scalar, their product is a directional vector quantity.
- Consequently, stating that momentum is not a vector quantity is false.

Why other options are incorrect:

- Option A:** In classical Newtonian mechanics, momentum was originally formulated as the fundamental quantity of motion.
- Option B:** The SI unit of momentum is $\text{kg} \cdot \text{m/s}$, which is dimensionally equivalent to newton-second ($\text{N} \cdot \text{s}$).
- Option D:** By definition, linear momentum is the algebraic product of an object's inertial mass and its velocity.

Question #58 Key: (C)PHYSICS
03. Work & Energy

How much work is done by the force of gravity in pulling a stone of weight 10 N from the top of...

CORE CONCEPT & DERIVATION

Work done by a constant downward gravitational force during vertical descent equals the product of the gravitational force (weight) and the vertical displacement.

Formula / Rule / Reaction:

$$W = \vec{F} \cdot \vec{d} = Fd \cos(0^\circ) = wh$$

Solution:

- The gravitational force acting on the stone is its weight, $w = 10 \text{ N}$, directed downwards.
- The displacement is $h = 250 \text{ m}$ downwards, parallel to gravity ($\theta = 0^\circ$).
- Computing the work done: $W = 10 \text{ N} \times 250 \text{ m} = 2500 \text{ J}$.

Why other options are incorrect:

- Option A:** 250 J corresponds to multiplying the displacement by a force of only 1 N.
- Option B:** 25 J is an arithmetic scaling error resulting from division by 10.
- Option D:** 25000 J represents an extra factor of 10, typically caused by incorrectly multiplying weight by g again.

Question #59 Key: (B)PHYSICS
03. Work & Energy

When the speed of your car is halved, by what factor does its kinetic energy decrease?

CORE CONCEPT & DERIVATION

Translational kinetic energy is directly proportional to the square of speed, meaning any fractional change in velocity results in a squared change in kinetic energy.

Formula / Rule / Reaction:

$$K = \frac{1}{2}mv^2 \implies K' = \frac{1}{2}m\left(\frac{v}{2}\right)^2 = \frac{1}{4}\left(\frac{1}{2}mv^2\right) = \frac{1}{4}K$$

Solution:

- Let the initial kinetic energy be $K_1 = \frac{1}{2}mv^2$.
- When the speed is halved, the new speed is $v' = \frac{v}{2}$.
- Substituting into the kinetic energy formula yields $K_2 = \frac{1}{2}m\left(\frac{v}{2}\right)^2 = \frac{1}{4}K_1$.
- The kinetic energy decreases by a factor of 4, becoming $\frac{1}{4}$ of its initial magnitude.

Why other options are incorrect:

- Option A:** $\frac{1}{2}$ assumes a linear relationship between kinetic energy and speed, which applies to momentum rather than kinetic energy.
- Option C:** $\frac{1}{8}$ would correspond to a cubic velocity dependence, such as wind power density.
- Option D:** $\frac{1}{6}$ has no mathematical foundation in quadratic kinematics.

Question #60 Key: (C)PHYSICS
04. Rotational & Circular Motion

One degree is equal to:

CORE CONCEPT & DERIVATION

Angular conversion between the sexagesimal system and the SI radian system is governed by the equivalence of 360 degrees to 2π radians.

Formula / Rule / Reaction:

$$1^\circ = \frac{\pi}{180} \text{ rad} = \frac{3.14159}{180} \text{ rad} \approx 0.017453 \text{ rad} \approx 0.0175 \text{ rad}$$

Solution:

- A complete circle subtends $360^\circ = 2\pi$ radians.
- Dividing both sides by 360 gives $1^\circ = \frac{\pi}{180}$ radians.
- Evaluating numerically: $\frac{3.1416}{180} \approx 0.017453 \text{ rad}$, which rounds to 0.0175 rad.

Why other options are incorrect:

- Option A:** 0.1 radian corresponds to an angle of approximately 5.73° .
- Option B:** 0.15 radian corresponds to an angle of approximately 8.59° .
- Option D:** 0.275 radian corresponds to an angle of approximately 15.76° .

Question #61 Key: (B)PHYSICS
04. Rotational & Circular Motion

If we double both the speed of the body and the radius of the circular path, the centripetal force...

CORE CONCEPT & DERIVATION

Centripetal force is directly proportional to the square of velocity and inversely proportional to the path radius.

Formula / Rule / Reaction:

$$F_c = \frac{mv^2}{r}$$

Solution:

- Let the initial centripetal force be $F_1 = \frac{mv^2}{r}$.
- If speed is doubled ($v' = 2v$) and radius is doubled ($r' = 2r$), the new centripetal force is:
- $$F_2 = \frac{m(2v)^2}{2r} = \frac{4mv^2}{2r} = 2\left(\frac{mv^2}{r}\right) = 2F_1$$
- Therefore, the centripetal force doubles.

Why other options are incorrect:

- Option A:** The force would remain unchanged only if radius were quadrupled when speed is doubled.
- Option C:** The force would quadruple if speed were doubled while the radius was kept constant.
- Option D:** An eight-fold increase would require speed to be doubled while radius was simultaneously halved.

Question #62 Key: (B)PHYSICS
05. Waves

Speed of sound is 332 m/s at 0°C. What will be its value at 10°C?

CORE CONCEPT & DERIVATION

The speed of sound in air increases linearly with Celsius temperature by approximately 0.61 m/s for every degree Celsius rise above 0°C.

Formula / Rule / Reaction:

$$v_t = v_0 + 0.61t$$

Solution:

- The baseline speed of sound at 0°C is $v_0 = 332$ m/s.
- For a temperature of $t = 10^\circ\text{C}$:
- $$v_{10} = 332 + (0.61 \times 10) = 332 + 6.1 = 338.1 \text{ m/s}$$

Why other options are incorrect:

- Option A:** 332 m/s is the reference speed at 0°C without thermal correction.
- Option C:** 332.61 m/s corresponds to a temperature increase of only 1°C.
- Option D:** 334.1 m/s reflects an arithmetic error in evaluating the thermal coefficient.

Question #63 Key: (C)PHYSICS
07. Thermodynamics

In molar specific heat, the equation [Formula] shows that:

CORE CONCEPT & DERIVATION

Mayer's relation shows that molar heat capacity at constant pressure exceeds that at constant volume because heat supplied at constant pressure must raise internal energy and perform external work.

Formula / Rule / Reaction:

$$C_p - C_v = R \implies C_p = C_v + R$$

Solution:

- Because the universal molar gas constant R is a positive physical constant ($R \approx 8.314 \text{ J/(mol} \cdot \text{K)}$), C_p must always exceed C_v .
- At constant volume, all heat input goes strictly into raising internal energy; at constant pressure, additional energy is expended to do boundary expansion work ($P\Delta V$) against the atmosphere.

Why other options are incorrect:

- Option A:** $C_p < C_v$ would imply that the gas constant R is negative, violating the first law of thermodynamics.
- Option B:** $C_p = C_v$ occurs only in completely incompressible substances where the thermal expansion coefficient is zero.
- Option D:** While C_p is constant for ideal gases over moderate temperature intervals, it does not explain the physical deduction of the equation.

Question #64 Key: (C)PHYSICS
07. Thermodynamics

The thermodynamic process during which volume of the system remains constant is:

CORE CONCEPT & DERIVATION

An isochoric (or isovolumetric) thermodynamic process takes place at constant volume, meaning no boundary work is performed by or on the system.

Formula / Rule / Reaction:

$$V = \text{constant} \implies \Delta V = 0 \implies W = P\Delta V = 0$$

Solution:

- In an isochoric process, the boundaries of the closed system are completely rigid and immobile.
- Because $\Delta V = 0$, mechanical work done is zero ($W = 0$), and by the first law of thermodynamics, all heat added directly increases internal energy ($Q = \Delta U$).

Why other options are incorrect:

- Option A:** An isothermal process occurs at constant temperature ($\Delta T = 0$).
- Option B:** An isobaric process occurs at constant pressure ($\Delta P = 0$).
- Option D:** An adiabatic process occurs without heat exchange with the surroundings ($Q = 0$).

Question #65 Key: (A)PHYSICS
08. Electrostatics

If two capacitors of capacitance [Formula] and [Formula] are connected in parallel, the equivalent...

CORE CONCEPT & DERIVATION

The equivalent capacitance of capacitors connected in parallel equals the direct algebraic sum of their individual capacitances.

Formula / Rule / Reaction:

$$C_{eq} = C_1 + C_2$$

Solution:

- In a parallel circuit configuration, the potential difference across each capacitor is identical while total stored charge is additive ($Q = Q_1 + Q_2$).

- Substituting the given values:

$$C_{eq} = 2 \mu F + 6 \mu F = 8 \mu F$$

Why other options are incorrect:

- Option B:** $\frac{3}{2} \mu F = 1.5 \mu F$ is the equivalent capacitance if the two capacitors were connected in series: $C_s = \frac{2 \times 6}{2+6} = 1.5 \mu F$.
- Option C:** $4 \mu F$ is the numerical difference between the two values ($6 - 2$).
- Option D:** $12 \mu F$ is the arithmetic product of the two values (2×6).

Question #66 Key: (C)PHYSICS
09. Current Electricity

Power transfer will be maximum when:

CORE CONCEPT & DERIVATION

According to the Maximum Power Transfer Theorem, maximum electrical power is transferred from a source with internal resistance r to a load resistor R when the load resistance matches the source resistance.

Formula / Rule / Reaction:

$$P = I^2 R = \frac{E^2 R}{(R+r)^2} \Rightarrow \frac{dP}{dR} = 0 \Rightarrow R = r$$

Solution:

- Differentiating the load power expression with respect to load resistance R and setting the first derivative to zero yields the matching condition:

$$(R+r)^2 - 2R(R+r) = 0 \Rightarrow R = r$$

- Under this impedance-matched condition, the maximum power dissipated across the load equals $P_{max} = \frac{E^2}{4r}$.

Why other options are incorrect:

- Option A:** When $R > r$, circuit current is restricted by excessive load impedance, reducing transferred power.
- Option B:** When $R < r$, internal power dissipation across the source resistance dominates, reducing power delivered to the load.
- Option D:** $R = 1/r$ is dimensionally inconsistent.

Question #67 Key: (D)PHYSICS
09. Current Electricity

A wire is stretched so that its radius of cross-section becomes half. Then resistance of the wire...

CORE CONCEPT & DERIVATION

When a wire is stretched, its total volume remains invariant, meaning a reduction in cross-sectional area results in a proportional elongation of length.

Formula / Rule / Reaction:

$$R = \rho \frac{L}{A} \quad \text{and} \quad V = AL = \text{constant}$$

Solution:

- The cross-sectional area of a cylindrical wire is $A = \pi r^2$. When the radius is halved ($r' = \frac{r}{2}$), the new area becomes:

$$A' = \pi \left(\frac{r}{2}\right)^2 = \frac{A}{4}$$

- Because volume remains constant ($V = A'L' = AL$), the new length is $L' = 4L$.

- The new electrical resistance is:

$$R' = \rho \frac{L'}{A'} = \rho \frac{4L}{A/4} = 16 \left(\rho \frac{L}{A}\right) = 16R$$

Why other options are incorrect:

- Option A:** $4R$ accounts only for the fourfold reduction in area while neglecting the simultaneous elongation in length.
- Option B:** $R/4$ would result from doubling the cross-sectional area without stretching.
- Option C:** $8R$ reflects an incomplete geometric derivation.

Question #68 Key: (C)PHYSICS
10. Electromagnetism

When a charged particle enters the magnetic field parallel, it:

CORE CONCEPT & DERIVATION

The magnetic Lorentz force on a charged particle is proportional to the sine of the angle between its velocity vector and the magnetic field vector.

Formula / Rule / Reaction:

$$\vec{F}_B = q(\vec{v} \times \vec{B}) \implies F_B = qvB \sin \theta$$

Solution:

- When a particle travels parallel to the magnetic field lines, the angle between velocity and magnetic field is $\theta = 0^\circ$.
- Because $\sin 0^\circ = 0$, the net magnetic deflecting force is zero ($F_B = 0$).
- By Newton's first law, the particle experiences no acceleration and continues along its original path in a straight line at constant velocity.

Why other options are incorrect:

- **Option A:** Magnetic deflection toward the North requires a non-zero transverse Lorentz force acting perpendicular to motion.
- **Option B:** Deflection toward the South requires a non-zero transverse Lorentz force.
- **Option D:** Circular motion occurs only when the charged particle enters strictly perpendicular ($\theta = 90^\circ$) to a uniform magnetic field.

Question #69 Key: (A)PHYSICS
10. Electromagnetism

Magnetic flux is maximum when the angle between the magnetic field and vector area is:

CORE CONCEPT & DERIVATION

Magnetic flux measures the dot product of the uniform magnetic field vector and the normal vector area representing the surface.

Formula / Rule / Reaction:

$$\Phi_B = \vec{B} \cdot \vec{A} = BA \cos \theta$$

Solution:

- The vector area $\vec{A}$ is defined perpendicular (normal) to the physical plane of the surface.
- The flux function reaches its maximum positive value when the cosine term is maximized:
- $\cos \theta = 1 \implies \theta = 0^\circ$
- Thus, when the magnetic field lines align parallel to the normal vector area (perpendicular to the surface plane), the flux is maximum.

Why other options are incorrect:

- **Option B:** At $\theta = 45^\circ$, $\cos 45^\circ = \frac{1}{\sqrt{2}} \approx 0.707$, yielding 70.7% of maximum flux.
- **Option C:** At $\theta = 90^\circ$, the field lines run parallel to the plane surface (perpendicular to the vector area), giving $\cos 90^\circ = 0$ and zero magnetic flux.
- **Option D:** At $\theta = 180^\circ$, $\cos 180^\circ = -1$, which represents maximum flux magnitude in the opposite relative orientation.

Question #70 Key: (A)PHYSICS
11. Electromagnetic Induction

The domestic electricity supply in Pakistan has a frequency of:

CORE CONCEPT & DERIVATION

The national electrical power grid in Pakistan adheres to International Electrotechnical Commission standards, operating at a nominal single-phase alternating current frequency of 50 Hz.

Formula / Rule / Reaction:

$$f = 50 \text{ Hz}, \quad V_{\text{rms}} = 230 \text{ V}$$

Solution:

- Grid utility alternators rotate at regulated speeds to generate alternating voltage completing 50 complete sinusoidal cycles per second.
- Domestic wall outlets in Pakistan deliver electricity at this standard frequency of 50 Hz.

Why other options are incorrect:

- **Option B:** 70 Hz is non-standard and is not employed by any public electrical grid.
- **Option C:** 100 Hz is double the supply frequency, representing the full-wave rectified ripple frequency rather than the generation frequency.
- **Option D:** 30 Hz is not an active utility standard.

Question #71 Key: (C)PHYSICS
11. Electromagnetic Induction

The device that increases or decreases the emf is called:

CORE CONCEPT & DERIVATION

A transformer is a static electromagnetic device that transfers electrical energy between circuits, stepping alternating voltages up or down via mutual induction.

Formula / Rule / Reaction:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Solution:

- A transformer consists of two insulated inductive coils wound on a common ferromagnetic core.
- When an alternating voltage is applied to the primary coil, the changing magnetic flux induces an electromotive force in the secondary coil whose magnitude is determined by the turns ratio (N_s/N_p).

Why other options are incorrect:

- **Option A:** An AC generator converts mechanical energy into electrical energy using electromagnetic induction.
- **Option B:** An electric motor converts electrical energy into mechanical work through magnetic torque.
- **Option D:** A DC generator generates unidirectional current from mechanical energy via a split-ring commutator.

Question #72 Key: (C)PHYSICS
11. Electromagnetic Induction

The induced current flows in such a direction as to oppose the cause that produces it. This sta...

CORE CONCEPT & DERIVATION

Lenz's law states that the direction of an induced current always opposes the change in magnetic flux that established the induced electromotive force.

Formula / Rule / Reaction:

$$\mathcal{E} = -N \frac{\Delta \Phi_B}{\Delta t}$$

Solution:

- Lenz's law provides the physical basis for the negative sign in Faraday's law of electromagnetic induction.
- This opposition is a direct manifestation of the law of conservation of energy; external mechanical work must be expended to induce electrical current.

Why other options are incorrect:

- **Option A:** Ampere's law relates the circulation of a magnetic field along a closed boundary to the electric current passing through the enclosed loop.
- **Option B:** Faraday's law quantifies the magnitude of induced electromotive force as proportional to the time rate of change of magnetic flux.
- **Option D:** Joule's law defines the rate of heat dissipation in an electrical conductor ($P = I^2 R$).

Question #73 Key: (B)PHYSICS
13. Electronics

The device used for conversion of AC into DC is:

CORE CONCEPT & DERIVATION

A rectifier is an electronic apparatus or circuit composed of semiconductor diodes configured to convert bidirectional alternating current into unidirectional direct current.

Formula / Rule / Reaction:

$$\text{Alternating Current (AC)} \xrightarrow{\text{Rectifier}} \text{Direct Current (DC)}$$

Solution:

- Rectifiers utilize one or more p-n junction diodes to restrict charge flow to a single direction.
- The entire assembly that receives alternating current input and produces a unidirectional output is designated a rectifier.

Why other options are incorrect:

- **Option A:** An amplifier increases the amplitude or voltage gain of an input signal without rectifying its waveform.
- **Option C:** A diode is the individual component used within a rectifier circuit, whereas the functional apparatus is called a rectifier.
- **Option D:** A transistor is a three-terminal semiconductor device used for amplification and switching.

Question #74 Key: (A)PHYSICS
13. Electronics

The process of conversion of AC into DC is called:

CORE CONCEPT & DERIVATION

Rectification is the physical and electronic process of converting alternating current into direct current.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Alternating current periodically alternates polarity across zero volts.
- The process of eliminating the negative half-cycle (half-wave) or inverting it into a positive output (full-wave) is defined as rectification.

Why other options are incorrect:

- **Option B:** Amplification is the process of boosting signal amplitude or power.
- **Option C:** Rectifier is the noun for the physical circuit or device, whereas the question asks for the name of the process.
- **Option D:** Conversion is an imprecise non-technical term.

Question #75 Key: (D)PHYSICS
16. Nuclear Physics

A 32 g phosphorus sample decays and 2 g remains undecayed after 60 days. The half-life of phosphorus...

CORE CONCEPT & DERIVATION

Radioactive decay follows first-order exponential kinetics where the mass of an undecayed radionuclide is halved after each successive half-life interval.

Formula / Rule / Reaction:

$$N(t) = N_0 \left(\frac{1}{2}\right)^n \quad \text{and} \quad T_{1/2} = \frac{t}{n}$$

Solution:

- Let the initial mass be $N_0 = 32$ g and the undecayed mass be $N(t) = 2$ g.
- Determining the number of elapsed half-lives (n):

$$\frac{N(t)}{N_0} = \frac{2}{32} = \frac{1}{16} = \left(\frac{1}{2}\right)^4 \implies n = 4 \text{ half-lives}$$

- With a total decay duration of $t = 60$ days, the half-life is:

$$T_{1/2} = \frac{60 \text{ days}}{4} = 15 \text{ days}$$

Why other options are incorrect:

- **Option A:** 5 days corresponds to 12 half-lives ($60/5$), leaving only $32/2^{12} \approx 0.0078$ g.
- **Option B:** 6 days corresponds to 10 half-lives, leaving $32/2^{10} \approx 0.031$ g.
- **Option C:** 10 days corresponds to 6 half-lives, leaving $32/2^6 = 0.5$ g.

Question #76 Key: (C)PHYSICS
16. Nuclear Physics

In nuclear radiography for medical diagnosis, which rays are used?

CORE CONCEPT & DERIVATION

Nuclear medicine imaging relies upon internally administered radioactive tracers that emit high-energy, highly penetrating gamma rays detected externally by scintillation cameras.

Formula / Rule / Reaction:

Factual recall / Qualitative concept.

Solution:

- Radiopharmaceuticals (such as Technetium-99m) emit gamma photons during nuclear de-excitation.
- Due to their high penetration and low ionization density, gamma rays exit the body with minimal soft-tissue absorption, enabling clear diagnostic organ imaging.

Why other options are incorrect:

- **Option A:** Alpha particles have very low penetration depth and high linear energy transfer, causing localized tissue ionization damage without exiting the body for detection.
- **Option B:** Ultraviolet rays are non-ionizing optical radiation unable to penetrate beyond epidermal skin layers.
- **Option D:** Diagnostic X-rays are generated extrinsically in vacuum tubes, whereas nuclear radiography relies on internal nuclear emissions.

Question #77 Key: (C)PHYSICS
02. Force & Motion

Unit of linear momentum is:

CORE CONCEPT & DERIVATION

Linear momentum is defined as the product of mass and velocity, which by the impulse-momentum theorem is dimensionally equivalent to newton-seconds ($\text{N} \cdot \text{s}$).

Formula / Rule / Reaction:

$$p = mv \implies [p] = \text{kg} \cdot \frac{\text{m}}{\text{s}} = \left(\text{kg} \cdot \frac{\text{m}}{\text{s}^2}\right) \cdot \text{s} = \text{N} \cdot \text{s}$$

Solution:

- Newton's second law expresses force as the time rate of change of momentum: $\vec{F} = \frac{\Delta \vec{p}}{\Delta t}$.
- Rearranging gives impulse: $\Delta \vec{p} = \vec{F} \Delta t$, yielding the SI unit $\text{N} \cdot \text{s}$.

Why other options are incorrect:

- **Option A:** $\text{N} \cdot \text{m}$ (joule) is the unit of mechanical work, energy, and torque.
- **Option B:** N/s represents the time rate of change of force, not momentum.
- **Option D:** $\text{N} \cdot \text{s}^2$ is dimensionally equivalent to $\text{kg} \cdot \text{m}$.

Question #78 **Key: (B)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals*When we went to cinema, the film _____.***CORE CONCEPT & DERIVATION**

When two past actions occur sequentially, the earlier completed event is expressed in the past perfect tense (had + past participle), while the later event is in the simple past.

Formula / Rule / Reaction:

Earlier Past Action: had + V_3 | Later Past Action: V_2

Solution:

- The arrival at the cinema is in the simple past ('went').
- The start of the film preceded this arrival, necessitating the past perfect tense 'had already started'.

Why other options are incorrect:

- **Option A:** 'Already started' is simple past and fails to mark temporal precedence over the other past action.
- **Option C:** 'Would already start' expresses conditional or habitual past actions rather than an antecedent historical event.
- **Option D:** 'Started already' lacks the auxiliary 'had' required to indicate completion before another past event.

Question #79 **Key: (B)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals*The soup _____ good.***CORE CONCEPT & DERIVATION**

Stative verbs of sensory perception take the simple present tense with singular third-person subjects and do not admit progressive aspects when describing an inherent quality.

Formula / Rule / Reaction:

Singular Subject (The soup) + Stative Linking Verb (V_1 + -s) + Subject Complement (good)

Solution:

- 'Soup' is an uncountable singular noun that requires the third-person singular verb ending 'tastes'.
- As a copular verb describing a state, 'taste' resists the continuous aspect.

Why other options are incorrect:

- **Option A:** 'Taste' is the plural base form, violating singular subject-verb agreement.
- **Option C:** 'Is tasting' denotes dynamic voluntary action by a person (e.g., 'the chef is tasting the soup'), which an inanimate object cannot perform.
- **Option D:** 'Will tasting' is ungrammatical modal auxiliary usage.

Question #80 **Key: (C)**ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals*She _____ unconscious since 4 o'clock.***CORE CONCEPT & DERIVATION**

A continuing condition that commenced at a definite point in the past and persists into the present requires the present perfect tense combined with 'since'.

Formula / Rule / Reaction:

Subject + has/have been + Adjective + since + Point in Time

Solution:

- The preposition 'since' designates the starting point of an ongoing condition.
- The present perfect form 'has been' correctly indicates a state that began at 4 o'clock and persists up to the present.

Why other options are incorrect:

- **Option A:** 'Is' is simple present and cannot be accompanied by 'since' specifying a past starting point.
- **Option B:** 'Was' is simple past and denotes a completed, terminated state rather than one extending to the present.
- **Option D:** 'Would' is a conditional auxiliary lacking a main lexical verb.

Question #81 **Key: (B)**ENGLISH
03. Parts of Speech, Prepositions & Modifiers*We will stay here _____ Monday.***CORE CONCEPT & DERIVATION**

Both 'till' and 'until' function as prepositions of time marking a terminal temporal boundary; 'till' is the board-keyed entry in this paper.

Formula / Rule / Reaction:

Action + till/until + Temporal Boundary (Monday)

Solution:

- The sentence specifies an action continuing up to a definite boundary in the future ('Monday').
- **Discrepancy Note:** While 'until' (Option A) and 'till' (Option B) are semantically identical prepositions in this context, the examination authority explicitly keyed 'till' (Option B).

Why other options are incorrect:

- **Option A:** 'Until' is grammatically correct in standard English, but 'till' was designated as the official key in this examination paper.
- **Option C:** 'Still' is an adverb of continuity, not a preposition governing a noun phrase.
- **Option D:** 'Since' requires a starting point in the past, not a terminal point in the future.

Question #82 Key: (B)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling*The word curiosity means:***CORE CONCEPT & DERIVATION**

Curiosity denotes an eager desire to learn, investigate, or know, which corresponds semantically to being keen (characterized by eager interest).

Formula / Rule / Reaction:*Lexical definition / Qualitative concept.***Solution:**

- Curiosity refers to inquisitiveness and the drive to explore new information.
- Among the available options, 'keen' conveys the sense of eager interest and active inquiry.

Why other options are incorrect:

- **Option A:** 'Cruel' means willfully causing pain or suffering.
- **Option C:** 'Angry' denotes experiencing hostility or wrath.
- **Option D:** 'Killing' refers to causing death.

Question #83 Key: (C)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling*Choose the correct spelling:***CORE CONCEPT & DERIVATION**

The noun designating a person who organizes and operates a business venture derives from the French verb 'entreprendre', spelled 'entrepreneur'.

Formula / Rule / Reaction:

Prefix (entre-) + Root (-pre-) + Suffix (-neur) = Entrepreneur

Solution:

- The word retains its French orthography: 'e-n-t-r-e-p-r-e-n-e-u-r'.
- Correct vowel distribution requires 'e' in both prefixes and '-eur' at the end.

Why other options are incorrect:

- **Option A:** 'Entreprenneur' erroneously replaces the second 'e' with 'i'.
- **Option B:** 'Enterpreneur' corrupts the French prefix 'entre-' to 'enter-'.
- **Option D:** 'Entreprineur' corrupts the penultimate vowel into 'i'.

Question #84 Key: (D)ENGLISH
03. Parts of Speech, Prepositions & Modifiers*DRAWBACK, this word is a combination of:***CORE CONCEPT & DERIVATION**

Compound nouns can be formed by combining a base verb with a directional adverb or spatial particle.

Formula / Rule / Reaction:

Draw (Verb) + Back (Adverb) = Drawback (Compound Noun)

Solution:

- 'Draw' is an action verb meaning to pull or take.
- 'Back' serves as an adverb specifying direction.
- Their combination forms the compound noun 'drawback', which denotes an unfavorable feature or disadvantage.

Why other options are incorrect:

- **Option A:** 'Back' functions here as a directional adverb rather than a descriptive adjective.
- **Option B:** 'Draw' is fundamentally a verb in this compound's morphological derivation.
- **Option C:** 'Back' indicates direction and acts as an adverb, not an object noun.

Question #85 Key: (D)ENGLISH
03. Parts of Speech, Prepositions & Modifiers*"Which is the next up train?" What does "up" represent here?***CORE CONCEPT & DERIVATION**

A word positioned immediately before a noun to restrict or describe its type functions as an attributive adjective.

Formula / Rule / Reaction:

Article (the) + Ordinal (next) + Adjective (up) + Head Noun (train)

Solution:

- In railway terminology, an 'up train' is a train traveling toward a main metropolitan center or capital.
- Because 'up' modifies the noun 'train', it functions syntactically as an adjective.

Why other options are incorrect:

- **Option A:** 'Up' is not functioning as a verb asserting an action.
- **Option B:** 'Up' is not the substantive head noun of the noun phrase.
- **Option C:** While 'up' often functions as an adverb when modifying verbs, here it directly modifies the noun 'train'.

Question #86 Key: (B)ENGLISH
04. Subject-Verb Agreement, Tenses & Conditionals

I wish I _____ the answer.

CORE CONCEPT & DERIVATION

Verbs expressing counterfactual or unreal present wishes require a past subjunctive form (simple past) in the subordinate clause.

Formula / Rule / Reaction:

Subject + wish + (that) + Subject + Past Subjunctive (V_2)

Solution:

- The matrix verb 'wish' conveys an unrealized desire in the present.
- In formal English grammar, expressing counterfactual present states requires backshifting the subordinate verb to the past subjunctive 'knew'.

Why other options are incorrect:

- **Option A:** 'Will know' expresses future indicative certainty, conflicting with counterfactual wishes.
- **Option C:** 'Have known' is present perfect indicative and cannot convey the subjunctive mood.
- **Option D:** 'Know' is simple present indicative; subjunctive wishes require the past tense form.

Question #87 Key: (B)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

What does the word "Analogue" mean?

CORE CONCEPT & DERIVATION

An analogue is something that bears a functional or structural resemblance to another entity, making it comparable.

Formula / Rule / Reaction:

Lexical definition / Qualitative concept.

Solution:

- Derived from the Greek 'analogos' (proportionate or corresponding), the term denotes an entity that corresponds to another in form or function.
- The closest equivalent synonym is 'comparable'.

Why other options are incorrect:

- **Option A:** 'Opposite' denotes antithesis or contrast, representing an antonym.
- **Option C:** 'Behind' is a spatial or temporal preposition.
- **Option D:** While dial clocks are termed 'analog', the general noun 'analogue' signifies something that is comparable.

Question #88 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

What does the word "Pulsating" mean?

CORE CONCEPT & DERIVATION

Pulsating is a participial adjective meaning expanding and contracting rhythmically or vibrating with regular beats, identical in meaning to 'throbbing'.

Formula / Rule / Reaction:

Lexical definition / Qualitative concept.

Solution:

- 'Pulsating' describes rhythmic, periodic surges or pulsations.
- The participle 'throbbing' directly matches 'pulsating' in both grammatical form and definition.

Why other options are incorrect:

- **Option B:** 'Pressure' is a physical force per unit area and functions as a noun rather than a rhythmic action.
- **Option C:** 'Fluid' refers to a flowing liquid or gas.
- **Option D:** 'Heart beat' is a compound noun identifying an organ's physiological contraction, whereas 'pulsating' is a descriptive participle.

Question #89 Key: (A)ENGLISH
01. Vocabulary, Synonyms, Antonyms & Spelling

The person in charge of a school is called:

CORE CONCEPT & DERIVATION

'Principal' functions as a noun denoting an administrative head of an educational institution, whereas its homophone 'principle' denotes a rule of conduct or fundamental truth.

Formula / Rule / Reaction:

Principal (Noun) = Administrative head of an educational institution

Solution:

- The noun 'principal' derives from the Latin 'principalis' (chief or leader).
- It designates the senior presiding administrative official of a school.

Why other options are incorrect:

- **Option B:** 'Principle' refers to a fundamental law, ethical guideline, or doctrine.
- **Option C:** 'Head' is incomplete in formal titles when compared directly with 'Principal'.
- **Option D:** 'Staff' refers collectively to employees rather than the individual in charge.

Question #90 Key: (C)ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

"Break a leg" is commonly used to:

CORE CONCEPT & DERIVATION

'Break a leg' is a conventional theatrical idiom used to wish someone good luck, especially before an artistic performance or public appearance.

Formula / Rule / Reaction:

Idiomatic expression / Qualitative concept.

Solution:

- The phrase originates from an old theatrical superstition that directly wishing good luck invites misfortune.
- Consequently, wishing a performer to 'break a leg' acts as an encouraging idiom meaning 'good luck'.

Why other options are incorrect:

- **Option A:** The expression is an encouraging wish, not a malevolent curse.
- **Option B:** The idiom is figurative and does not advocate bodily injury.
- **Option D:** 'Teach someone a lesson' means to punish someone to deter bad behavior.

Question #91 Key: (B)ENGLISH
02. Idioms, Phrasal Verbs & Literary Figures

"Bite the bullet" is commonly used to:

CORE CONCEPT & DERIVATION

The idiom 'bite the bullet' means to face a difficult or unpleasant situation with courage and accept unavoidable consequences without flinching.

Formula / Rule / Reaction:

Idiomatic expression / Qualitative concept.

Solution:

- The idiom derives from historical military field surgery, where wounded soldiers bit on lead bullets to endure pain without anesthesia.
- In idiomatic usage, it means enduring hardship and accepting unpleasant consequences.

Why other options are incorrect:

- **Option A:** Accepting defeat is conveyed by expressions like 'throw in the towel'.
- **Option C:** The idiom indicates enduring a painful ordeal, not accepting death.
- **Option D:** 'Bad faith' denotes deliberate deceit, which is unrelated to the endurance implied by the idiom.