IIT JAM Biotechnology

Sample Paper – 1

Collegedunia Practice Series | Exam Date: 14 February 2027

Instructions

- This paper contains **60 questions** carrying a maximum of **100 marks**. Duration: **3 hours (180 minutes)**.
- **Section A** (**Q1–Q30**, MCQ): Q1–Q10 carry **+1 mark** each; wrong response: $-\frac{1}{3}$ mark. Q11–Q30 carry **+2 marks** each; wrong response: $-\frac{2}{3}$ mark. Choose the **single best** option.
- **Section B** (**Q31–Q40**, MSQ): Each carries **+2 marks**. **No negative marking.** One or more options may be correct; full marks only if *all* correct options are selected; no partial credit.
- **Section C** (**Q41–Q60**, NAT): Q41–Q50 carry **+1 mark**; Q51–Q60 carry **+2 marks**. **No negative marking.** Enter the numerical answer using the virtual keypad.
- **No calculators, log tables, or electronic devices.** A virtual scientific calculator is provided in the CBT interface.

Section A — Multiple Choice Questions (MCQ)

***Q1–Q10**: 1 mark each ($-\frac{1}{3}$ for wrong). Choose the **single** correct option.*

Q1. In a monohybrid cross between two heterozygous individuals (Aa $\times$ Aa), what fraction of the offspring will be heterozygous (Aa)?

	A	**a**
A	AA	Aa
a	Aa	aa

(A) $\frac{1}{4}$
(B) $\frac{3}{4}$
(C) $\frac{1}{2}$
(D) 1

Q2. The organelle that is the primary site of ATP synthesis via oxidative phosphorylation in eukaryotic cells is:

(A) Ribosome

(B) Mitochondria
(C) Golgi apparatus
(D) Nucleus

Q3. The Gram staining property of bacteria is primarily determined by differences in their:

(A) Ribosome size
(B) DNA content
(C) Flagella composition
(D) Cell wall peptidoglycan thickness

Q4. Which of the following amino acids contains a sulfur atom in its side chain?

(A) Cysteine
(B) Serine
(C) Glycine
(D) Alanine

Q5. Which condition must be satisfied for a population to remain in Hardy–Weinberg genetic equilibrium?

(A) Small population size
(B) High mutation rate
(C) Non-random mating
(D) No natural selection

Q6. According to Chargaff's rules for double-stranded DNA, which of the following is correct?

(A) $[\mathrm{A}] = [\mathrm{T}]$ and $[\mathrm{G}] = [\mathrm{C}]$
(B) $[\mathrm{A}] = [\mathrm{G}]$ and $[\mathrm{C}] = [\mathrm{T}]$
(C) $[\mathrm{A}] = [\mathrm{C}]$ and $[\mathrm{G}] = [\mathrm{T}]$
(D) $[\mathrm{A}] + [\mathrm{T}] = [\mathrm{G}] + [\mathrm{C}]$

Q7. A bacterial culture starts with 10^3 cells. After 2 hours the count is 16×10^3 cells. The doubling time is:

(A) 20 min
(B) 45 min
(C) 30 min
(D) 60 min

Q8. Activation of phospholipase C (PLC) by a G-protein-coupled receptor produces which second messengers?

(A) IP_3 and diacylglycerol (DAG)
(B) cAMP
(C) cGMP
(D) Arachidonic acid

Q9. The enzyme that synthesises a new DNA strand by extending an RNA primer during DNA replication is:

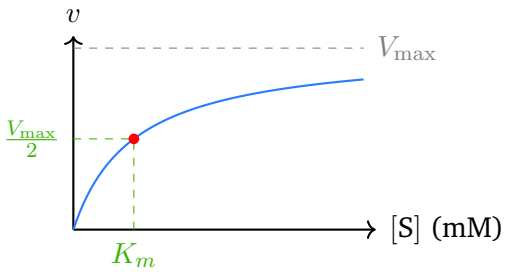
(A) DNA helicase
(B) DNA ligase
(C) DNA polymerase
(D) Topoisomerase

Q10. The protein coat that surrounds and protects the viral genome is called the:

(A) Capsid
(B) Envelope
(C) Peplomer
(D) Replicase

***Q11–Q30**: 2 marks each ($-\frac{2}{3}$ for wrong). Choose the **single** correct option.*

Q11. An enzyme has $K_m = 2\,\text{mM}$ and $V_{\max} = 100\,\mu\text{mol/min}$. The initial velocity at $[\text{S}] = 2\,\text{mM}$ is:



(A) $50\,\mu$mol/min
(B) $25\,\mu$mol/min
(C) $75\,\mu$mol/min
(D) $100\,\mu$mol/min

Q12. Starting with 1 double-stranded template molecule, the theoretical number of PCR product copies after 30 cycles is approximately:

(A) 30
(B) 300
(C) 2^{29}
(D) 2^{30}

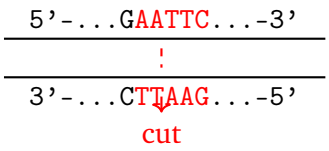
Q13. The transition from G_2 to M phase (entry into mitosis) is primarily triggered by the activation of:

(A) Cyclin D–CDK4 complex
(B) Cyclin B–CDK1 (MPF) complex
(C) Cyclin A–CDK2 complex
(D) Cyclin E–CDK2 complex

Q14. The modern estimate of the net ATP yield from complete aerobic oxidation of one molecule of glucose in eukaryotes (using P/O ratios of 2.5 for NADH and 1.5 for $FADH_2$) is approximately:

(A) 30–32 ATP
(B) 36–38 ATP
(C) 4 ATP
(D) 15–18 ATP

Q15. The restriction enzyme EcoRI recognises the 6-bp sequence 5′-GAATTC-3′. Assuming 50% GC content and random sequence, the expected average frequency of EcoRI sites is one site per:



(A) 1024 bp
(B) 4096 bp
(C) 256 bp
(D) 16384 bp

Q16. Which immunoglobulin isotype crosses the placenta to provide passive immunity to the fetus?

(A) IgA
(B) IgM
(C) IgE
(D) IgG

Q17. The Shine–Dalgarno sequence in prokaryotic mRNA base-pairs with:

(A) tRNA anticodon loop
(B) 23S rRNA
(C) 50S ribosomal protein L11
(D) The 3′ end of 16S rRNA

Q18. In a dihybrid cross AaBb $\times$ AaBb, the fraction of offspring showing *both* dominant phenotypes is:

(A) $\frac{1}{16}$
(B) $\frac{9}{16}$
(C) $\frac{3}{16}$
(D) $\frac{4}{16}$

Q19. The enzyme complex responsible for the oxidative decarboxylation of pyruvate to acetyl-CoA in the mitochondrial matrix is:

(A) Pyruvate kinase
(B) Pyruvate dehydrogenase complex (PDH)
(C) Isocitrate dehydrogenase
(D) Succinate dehydrogenase

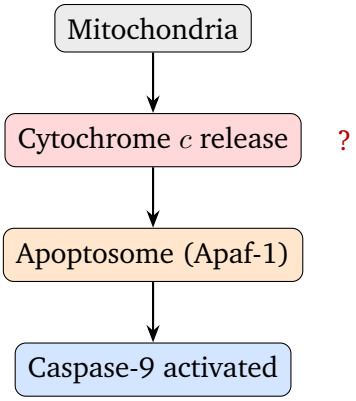
Q20. The determinant of the matrix $M = \begin{pmatrix} 3 & 1 \\ 2 & 4 \end{pmatrix}$ is:

(A) 10
(B) 5
(C) 14
(D) 8

Q21. In the *E. coli* lac operon, the true inducer that binds the lac repressor and inactivates it is:

(A) Glucose
(B) Lactose
(C) Allolactose
(D) Galactose-1-phosphate

Q22. In the intrinsic apoptosis pathway, which event directly triggers the activation of caspase-9?



(A) Fas ligand binding to Fas receptor
(B) TRAIL receptor activation
(C) Activation of caspase-8
(D) Release of cytochrome c from mitochondria

Q23. A competitive inhibitor of an enzyme results in:

(A) Decreased $V_{\max}$ and increased apparent K_m
(B) Unchanged $V_{\max}$ and increased apparent K_m
(C) Decreased $V_{\max}$ and unchanged K_m
(D) Unchanged $V_{\max}$ and unchanged K_m

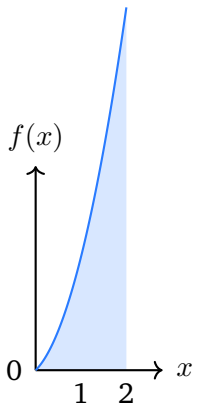
Q24. The antigen-binding region of an antibody molecule is located in the:

(A) Fc region
(B) CH2 constant domain
(C) Hinge region
(D) Fab (fragment antigen binding) region

Q25. Which combination of traits best characterises r-selected species?

(A) Long lifespan, few offspring, high parental investment
(B) High reproductive rate, small body size, short lifespan
(C) Slow maturation, stable populations at carrying capacity
(D) Low growth rate even in resource-rich environments

Q26. The value of $\int_0^2 (3x^2 + 2x)\,dx$ is:



(A) 8
(B) 10
(C) 12
(D) 16

Q27. Which of the following vectors is most suitable for cloning DNA fragments larger than 100 kb?

(A) pUC19 plasmid (∼2 kb insert limit)
(B) Lambda phage (∼20 kb insert limit)
(C) Bacterial Artificial Chromosome (BAC)
(D) Cosmid (∼45 kb insert limit)

Q28. The DNA repair pathway that specifically corrects base-pair mismatches introduced during DNA replication is:

(A) Base excision repair (BER)
(B) Mismatch repair (MMR)
(C) Nucleotide excision repair (NER)
(D) Photoreactivation

Q29. Aquaporins facilitate the movement of water across cell membranes by:

(A) Forming a water-selective protein channel (passive)
(B) Active transport using ATP hydrolysis
(C) Cotransport with Na^+ ions
(D) Endocytosis of water molecules

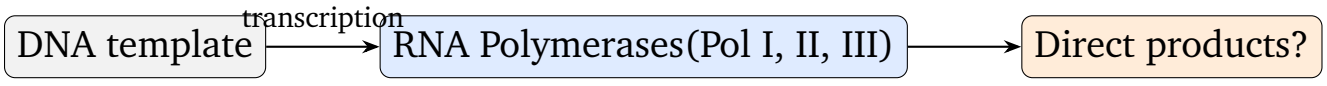
Q30. Using modern P/O ratios, each $FADH_2$ oxidised through the mitochondrial electron transport chain yields approximately:

(A) 1 ATP
(B) 1.5 ATP
(C) 2.5 ATP
(D) 3 ATP

Section B — Multiple Select Questions (MSQ)

***Q31–Q40**: 2 marks each. **No negative marking.** One or more options may be correct. Full marks only if* all *correct options are selected.*

Q31. Which of the following are *direct* products of transcription in eukaryotes?



(A) Pre-mRNA (primary transcript, before splicing)
(B) Mature mRNA (after splicing and polyadenylation)
(C) rRNA (ribosomal RNA transcribed by RNA Pol I)
(D) Protein (translated from mRNA)

Q32. Which of the following organelles contain their own genome (DNA)?

(A) Golgi apparatus
(B) Mitochondria
(C) Chloroplasts
(D) Endoplasmic reticulum

Q33. Which of the following metabolic pathways occur in the mitochondrial matrix?

(A) Glycolysis
(B) Fatty acid synthesis
(C) Tricarboxylic acid (TCA) cycle
(D) Pyruvate decarboxylation (pyruvate dehydrogenase reaction)

Q34. Which of the following are characteristics of Gram-positive bacteria?

(A) Thick peptidoglycan layer
(B) Presence of an outer membrane
(C) Greater susceptibility to penicillin compared to Gram-negative bacteria
(D) Teichoic acids embedded in the cell wall

Q35. Which of the following are *essential* components of a standard PCR reaction?

(A) Thermostable DNA polymerase (e.g., Taq)
(B) RNA polymerase
(C) DNA oligonucleotide primers
(D) Ligase

Q36. Which of the following statements about allosteric enzymes are correct?

(A) They always obey standard Michaelis–Menten kinetics
(B) They exhibit sigmoidal (S-shaped) velocity vs. [S] curves
(C) Allosteric effectors bind at the catalytic active site
(D) They can exhibit both homotropic and heterotropic effects

Q37. Which of the following inheritance patterns exemplify *co-dominance*?

(A) ABO blood group system (type AB individuals)
(B) MN blood group system
(C) Red-green colour blindness
(D) Sickle cell anaemia (recessive inheritance)

Q38. Which of the following are key events that occur during the S phase of the cell cycle?

(A) DNA replication (genome duplication)
(B) Formation of the mitotic spindle
(C) Histone synthesis (to package newly replicated DNA)
(D) Cytokinesis

Q39. Which of the following are post-transcriptional modifications that occur during eukaryotic pre-mRNA processing?

(A) Addition of CCA sequence at the 3′ end (tRNA modification)
(B) Base methylation of tRNA wobble position
(C) 5′ capping with 7-methylguanosine
(D) 3′ polyadenylation (addition of poly-A tail)

Q40. Which of the following statements about enzyme inhibitors are correct?

(A) Non-competitive inhibitors increase the apparent K_m
(B) Uncompetitive inhibitors decrease both apparent K_m and $V_{\max}$
(C) Competitive inhibitors decrease $V_{\max}$
(D) Irreversible inhibitors form covalent bonds with the enzyme

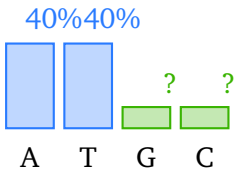
Section C — Numerical Answer Type (NAT)

Q41–Q50**: 1 mark each. **No negative marking.

Q41. A bacterial culture starts with 10^3 CFU/mL. The doubling time is 30 min. The number of cells (in thousands, $\times 10^3$ CFU/mL) after exactly 2 hours is:

Q42. How many peptide bonds are present in a polypeptide chain of 25 amino acids?

Q43. A double-stranded DNA molecule contains 40% Adenine residues. The percentage of Cytosine residues is:



Q44. The number of codons in the standard genetic code that specify the amino acid **Leucine** is:

Q45. In a randomly mating population, the frequency of allele A is 0.3 and the frequency of allele a is 0.7. According to Hardy–Weinberg equilibrium, the expected frequency of heterozygotes (Aa) as a decimal is:

Q46. The number of phosphodiester bonds in a linear single-stranded RNA molecule containing 15 nucleotides is:

Q47. The total number of NADH molecules produced when one molecule of pyruvate is completely oxidised to CO_2 via the pyruvate dehydrogenase reaction and one turn of the TCA cycle is:

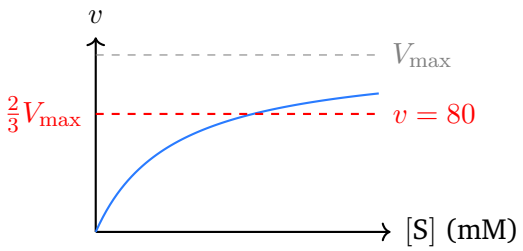
Q48. The half-life of ^{32}P is approximately 14 days. The fraction of a ^{32}P sample remaining after 42 days is (express as a decimal):

Q49. The pH of a solution containing 0.001 M NaOH (fully dissociated, at 25°C) is:

Q50. A circular DNA molecule of 12288 bp is treated with a restriction enzyme that recognises a 6-bp sequence (average cut frequency: 1 site per 4096 bp). The expected number of fragments generated is:

Q51–Q60: 2 marks each. ***No negative marking.***

Q51. An enzyme has $K_m = 4\,\text{mM}$ and $V_{\max} = 120\,\mu\text{mol/min}$. Calculate the substrate concentration [S] (in mM) at which the reaction velocity $v = 80\,\mu\text{mol/min}$.



Q52. In a testcross (AaBb $\times$ aabb), what is the expected number of offspring with genotype AaBb if 400 total offspring are produced?

Q53. The eigenvalues of the matrix $A = \begin{pmatrix} 5 & 2 \\ 2 & 2 \end{pmatrix}$ are obtained from $\det(A - \lambda I) = 0$. The *larger* eigenvalue is:

Q54. For a normal distribution with mean $\mu = 10$ and standard deviation $\sigma = 2$, the probability $P(8 < X < 12)$ is approximately (use the empirical rule; give 2 decimal places):

Q55. A bacterial population starts with 500 cells and grows exponentially with rate constant $k = 0.023\,\text{min}^{-1}$. The approximate number of cells after 60 minutes (rounded to the nearest 100) is:

Q56. The value of the double integral $\iint_D dA$ over the rectangular region $D : \{(x, y) : 0 \le x \le 3,\ 0 \le y \le 2\}$ is:

Q57. A gene locus has two alleles. In a population the genotype frequencies are: AA = 32%, Aa = 48%, aa = 20%. The frequency of allele A (to 2 decimal places) is:

Q58. A bacterial culture grows from 10^5 to 8×10^5 CFU in 90 minutes. The generation (doubling) time in minutes is:

Q59. The approximate molecular weight (in Daltons) of a protein consisting of 150 amino acid residues, assuming an average residue mass of 110 Da, is:

Q60. In a population of 1000 individuals, 90 have blood type O (genotype ii). Assuming only I^A and i alleles exist and Hardy–Weinberg equilibrium holds, the frequency of the i allele (to 2 decimal places) is:

Answer Key — IIT JAM Biotechnology Sample Paper 1

Section A — MCQ (Q1–Q30)

Q	Ans	Q	Ans	Q	Ans	Q	Ans	Q	Ans
1	C	2	B	3	D	4	A	5	D
6	A	7	C	8	A	9	C	10	A
11	A	12	D	13	B	14	A	15	B
16	D	17	D	18	B	19	B	20	A
21	C	22	D	23	B	24	D	25	B
26	C	27	C	28	B	29	A	30	B

Section B — MSQ (Q31–Q40)

Q	Correct options	Q	Correct options
31	(A) and (C)	36	(B) and (D)
32	(B) and (C)	37	(A) and (B)
33	(C) and (D)	38	(A) and (C)
34	(A), (C) and (D)	39	(C) and (D)
35	(A) and (C)	40	(B) and (D)

Section C — NAT (Q41–Q60)

Q	Answer	Q	Answer	Q	Answer	Q	Answer
41	16	46	14	51	8	56	6
42	24	47	4	52	100	57	0.56
43	10	48	0.125	53	6	58	30
44	6	49	11	54	0.68	59	16500
45	0.42	50	3	55	2000	60	0.30

Detailed Solutions

SECTION A — MCQ

Q1. **Answer: (C)**

Solution

From the Punnett square: AA : Aa : aa = 1:2:1. Heterozygous (Aa) = $\frac{2}{4} = \frac{1}{2}$. **(C)**

Q2. **Answer: (B)**

Solution

Mitochondria house the electron transport chain and ATP synthase (Complex V), making them the primary site of oxidative phosphorylation. **(B)**

Q3. **Answer: (D)**

Solution

Gram-positive bacteria retain crystal violet due to their *thick* peptidoglycan layer; Gram-negative bacteria have a thin peptidoglycan layer plus an outer membrane and decolourize. **(D)**

Q4. **Answer: (A)**

Solution

Cysteine (-CH_2-SH) has a thiol group. Serine has -OH; Glycine has -H; Alanine has -CH_3. **(A)**

Q5. **Answer: (D)**

Solution

Hardy-Weinberg requires: random mating, no mutation, no migration, large population size, and *no natural selection*. **(D)**

Q6. **Answer: (A)**

Solution

Chargaff's rules: in any dsDNA, [A]=[T] and [G]=[C] (complementary base pairing). Option (D) would imply equal proportions of AT and GC which is only true for specific sequences. **(A)**

Q7. **Answer: (C)**

Solution

$10^3 \to 16 \times 10^3$ = 4 doublings. Time for 4 doublings = 120 min. Doubling time = $120/4 = 30$ min. **(C)**

Q8. **Answer: (A)**

Solution

PLC cleaves PIP_2 into **IP_3** (triggers Ca^{2+} release from ER) and **DAG** (activates PKC). **(A)**

Q9. **Answer: (C)**

Solution

DNA polymerase (III in prokaryotes; δ/ε in eukaryotes) elongates the new strand by adding dNTPs at the 3′-OH of an existing primer. **(C)**

Q10. **Answer: (A)**

Solution

The **capsid** is the protein coat surrounding the viral genome. The envelope (when present) is a lipid bilayer derived from the host cell membrane and lies outside the capsid. **(A)**

Q11. **Answer: (A)**

Solution

Michaelis–Menten: $v = \dfrac{V_{\max}[\mathrm{S}]}{K_m + [\mathrm{S}]} = \dfrac{100 \times 2}{2+2} = \dfrac{200}{4} = 50\,\mu$mol/min. At $[\mathrm{S}] = K_m$, $v = V_{\max}/2$. **(A)**

Q12. **Answer: (D)**

Solution

After n PCR cycles starting from 1 dsDNA molecule, approximately 2^n copies are produced. For $n = 30$: $2^{30} \approx 10^9$. **(D)**

Q13. **Answer: (B)**

Solution

Cyclin B accumulates in G_2 and activates CDK1 (also called Cdc2). The Cyclin B–CDK1 complex (MPF, Maturation Promoting Factor) phosphorylates substrates to drive mitotic entry. **(B)**

Q14. **Answer: (A)**

Solution

Using modern P/O ratios (NADH→2.5 ATP; $FADH_2$ →1.5 ATP): cytoplasmic glycolysis gives 2 ATP + 2 NADH (5 ATP via NADH at 2.5); PDH gives 2 NADH (5 ATP); TCA gives 6 NADH (15), 2 $FADH_2$ (3), 2 GTP (2): total ≈ 30–32 ATP. **(A)**

Q15. **Answer: (B)**

Solution

For a 6-bp recognition sequence with 4 equally probable bases: frequency $= (1/4)^6 = 1/4096$ bp. **(B)**

Q16. **Answer: (D)**

Solution

Only IgG can cross the placenta via neonatal Fc receptor (FcRn)-mediated transcytosis, providing maternal passive immunity to the fetus. **(D)**

Q17. **Answer: (D)**

Solution

The Shine–Dalgarno (SD) sequence (consensus 5′-AGGAGG-3′) is complementary to a sequence near the 3′ end of 16S rRNA, facilitating 30S ribosome binding during translation initiation. **(D)**

Q18. **Answer: (B)**

Solution

Standard 9:3:3:1 ratio from AaBb×AaBb. Fraction showing both dominant phenotypes (A_B_) $= 9/16$. **(B)**

Q19. **Answer: (B)**

Solution

The pyruvate dehydrogenase complex (PDH; a multi-enzyme complex of E1, E2, E3) catalyses: Pyruvate + CoA + $NAD^+ \rightarrow$ Acetyl-CoA + CO_2 + NADH. Located in the mitochondrial matrix. **(B)**

Q20. **Answer: (A)**

Solution

$\det(M) = 3 \times 4 - 1 \times 2 = 12 - 2 =$ **10. (A)**

Q21. **Answer: (C)**

Solution

Lactose is first converted by basal β-galactosidase to **allolactose** (1-6 galactosyl-glucose linkage), which is the true inducer that binds and inactivates the lac repressor. **(C)**

Q22. **Answer: (D)**

Solution

In the intrinsic pathway: cellular stress $\rightarrow$ mitochondrial outer membrane permeabilisation $\rightarrow$ **release of cytochrome** c $\rightarrow$ cytochrome c + Apaf-1 + procaspase-9 form the apoptosome $\rightarrow$ caspase-9 activation. **(D)**

Q23. **Answer: (B)**

Solution

A competitive inhibitor occupies the active site reversibly. With excess substrate, the inhibitor is displaced, so $V_{\max}$ is *unchanged*. It increases the apparent K_m (more substrate needed to reach half-maximal velocity). **(B)**

Q24. **Answer: (D)**

Solution

The Fab (Fragment Antigen Binding) region contains the variable domains (VH and VL) that form the CDR loops responsible for antigen binding. The Fc region mediates effector functions. **(D)**

Q25. **Answer: (B)**

Solution

r-strategists: high reproductive rate, many small offspring, short generation time, small body size, opportunistic. K-strategists are the opposite (stable environments, high parental investment). **(B)**

Q26. **Answer: (C)**

Solution

$\int_0^2 (3x^2 + 2x)\,dx = \left[x^3 + x^2\right]_0^2 = (8+4) - (0+0) = \mathbf{12}$. **(C)**

Q27. **Answer: (C)**

Solution

BAC (Bacterial Artificial Chromosome) accepts inserts of 100–350 kb. Lambda: ∼20 kb; Cosmids: ∼45 kb; pUC19: ∼2–4 kb. **(C)**

Q28. **Answer: (B)**

Solution

MMR proteins (MutS, MutL, MutH in prokaryotes; MSH and MLH homologs in eukaryotes) recognise base mismatches and insertion/deletion loops introduced during replication and repair them. **(B)**

Q29. **Answer: (A)**

Solution

Aquaporins (AQP) are integral membrane proteins that form selective channels through which water molecules move by osmosis (passive transport, down its concentration gradient). No ATP is consumed. **(A)**

Q30. **Answer: (B)**

Solution

$FADH_2$ donates electrons at Complex II, bypassing Complex I. Using the modern P/O ratio: $FADH_2 \rightarrow \approx 1.5$ ATP. **(B)**

SECTION B — MSQ

Q31. **Answer: (A,C)**

Solution

(A) Pre-mRNA is the direct product of RNA Pol II transcription. (C) rRNA is the direct product of RNA Pol I transcription. Mature mRNA (B) requires splicing/capping/polyadenylation; protein (D) is a translation product. **Correct: (A) and (C)**

Q32. **Answer: (B,C)**

Solution

Mitochondria (B) and chloroplasts (C) both contain circular DNA, reflecting their endosymbiotic prokaryotic ancestors. Golgi (A) and ER (D) contain no DNA. **Correct: (B) and (C)**

Q33. **Answer: (C,D)**

Solution

TCA cycle (C) and pyruvate decarboxylation by PDH complex (D) both occur in the mitochondrial matrix. Glycolysis (A) occurs in the cytoplasm; fatty acid synthesis (B) occurs primarily in the cytoplasm (cytosol). **Correct: (C) and (D)**

Q34. **Answer: (A,C,D)**

Solution

Gram-positive bacteria have: a thick (∼20–80 nm) peptidoglycan layer (A), are more susceptible to penicillin than Gram-negative bacteria because they lack the outer membrane permeability barrier (C), and possess teichoic acids in their cell walls (D). Option B (outer membrane) is a Gram-negative feature. **Correct: (A), (C) and (D)**

Q35. **Answer: (A,C)**

Solution

PCR requires (A) a thermostable DNA polymerase (Taq, Phusion, etc.) and (C) sequence-specific oligonucleotide primers to prime synthesis. RNA polymerase (B) and ligase (D) are not components of PCR. **Correct: (A) and (C)**

Q36. **Answer: (B,D)**

Solution

Allosteric enzymes show sigmoidal kinetics (B), not hyperbolic. They can exhibit homotropic effects (cooperativity with substrate) and heterotropic effects (activation/inhibition by a different molecule) (D). Effectors bind at allosteric sites, not the active site (C incorrect). **Correct: (B) and (D)**

Q37. **Answer: (A,B)**

Solution

Co-dominance: both alleles are fully expressed. ABO type AB shows both A and B antigens (A); MN blood group shows both M and N antigens (B). Colour blindness (C) is X-linked recessive; sickle cell anaemia (D) shows incomplete dominance/codominance at molecular level but is classically recessive at phenotype. **Correct: (A) and (B)**

Q38. **Answer: (A,C)**

Solution

During S phase: DNA replication (A) duplicates the genome, and histone synthesis (C) is upregulated to package the new DNA into nucleosomes. Spindle formation (B) occurs in M phase; cytokinesis (D) occurs at the end of M phase. **Correct: (A) and (C)**

Q39. **Answer: (C,D)**

Solution

Eukaryotic pre-mRNA processing includes 5′ capping with 7-methyl-guanosine (C) and 3′ polyadenylation (D). CCA addition (A) is specific to tRNA; base methylation at tRNA wobble positions (B) is tRNA processing. **Correct: (C) and (D)**

Q40. **Answer: (B,D)**

Solution

Uncompetitive inhibitors bind only the ES complex, decreasing both apparent K_m and $V_{\max}$ (B). Irreversible inhibitors (e.g., DFP for serine proteases) form stable covalent adducts with the enzyme (D). Non-competitive inhibitors do not change K_m (A incorrect); competitive inhibitors do not decrease $V_{\max}$ (C incorrect). **Correct: (B) and (D)**

SECTION C — NAT

Q41. **Answer: (16)**

Solution

$t = 2\,\text{h} = 120\,\text{min}$. Number of doublings $= 120/30 = 4$. $N = 10^3 \times 2^4 = 16 \times 10^3$. Answer: **16** (in units of 10^3 CFU/mL).

Q42. **Answer: (24)**

Solution

A polypeptide of n amino acids has $n - 1$ peptide bonds. For $n = 25$: $25 - 1 = \mathbf{24}$.

Q43. **Answer: (10)**

Solution

Chargaff: $[\text{A}] = [\text{T}] = 40\%$. Therefore $[\text{G}] + [\text{C}] = 20\%$, and since $[\text{G}] = [\text{C}]$: $[\text{C}] = \mathbf{10}\%$.

Q44. **Answer: (6)**

Solution

Leucine codons: UUA, UUG (Leu, decoded via U in first position) and CUU, CUC, CUA, CUG (decoded via C in first position). Total = **6**.

Q45. **Answer: (0.42)**

Solution

Hardy–Weinberg: frequency of $Aa = 2pq = 2 \times 0.3 \times 0.7 = \mathbf{0.42}$.

Q46. **Answer: (14)**

Solution

In a linear nucleic acid chain of n nucleotides, there are $n-1$ phosphodiester bonds. For $n = 15$: $15 - 1 = \mathbf{14}$.

Q47. **Answer: (4)**

Solution

From 1 pyruvate: PDH reaction $\rightarrow$ 1 NADH. TCA cycle (1 turn): isocitrate dehydrogenase $\rightarrow$ 1 NADH, α-ketoglutarate dehydrogenase $\rightarrow$ 1 NADH, malate dehydrogenase $\rightarrow$ 1 NADH. Total NADH = $1 + 3 = \mathbf{4}$.

Q48. **Answer: (0.125)**

Solution

$42\,\text{d}/14\,\text{d} = 3$ half-lives. Fraction remaining $= (1/2)^3 = 1/8 = \mathbf{0.125}$.

Q49. **Answer: (11)**

Solution

$[\text{OH}^-] = 0.001$ M. pOH $= -\log(10^{-3}) = 3$. pH $= 14 - 3 = \mathbf{11}$.

Q50. **Answer: (3)**

Solution

A circular DNA of 12288 bp with cuts every 4096 bp: $12288/4096 = 3$ cuts. A circular molecule with 3 cuts yields **3** linear fragments.

Q51. **Answer: (8)**

Solution

$v = \dfrac{V_{\max}[\text{S}]}{K_m + [\text{S}]}$: $80 = \dfrac{120[\text{S}]}{4 + [\text{S}]}$. Solving: $80(4 + [\text{S}]) = 120[\text{S}]$; $320 = 40[\text{S}]$; $[\text{S}] = \mathbf{8}$ mM.

Q52. **Answer: (100)**

Solution

AaBb $\times$ aabb gives four equally probable genotypes: AaBb : Aabb : aaBb : aabb = 1:1:1:1. Frequency of AaBb $= 1/4$. Expected number $= 400 \times (1/4) = \mathbf{100}$.

Q53. **Answer: (6)**

Solution

$\det(A - \lambda I) = (5 - \lambda)(2 - \lambda) - 4 = \lambda^2 - 7\lambda + 6 = (\lambda - 1)(\lambda - 6) = 0$. Eigenvalues: $\lambda = 1$ and $\lambda = 6$. Larger eigenvalue $= \mathbf{6}$.

Q54. **Answer: (0.68)**

Solution

By the empirical (68–95–99.7) rule: $P(\mu - \sigma < X < \mu + \sigma) = P(8 < X < 12) \approx \mathbf{0.68}$ (68.27%).

Q55. **Answer: (2000)**

Solution

$N = N_0 e^{kt} = 500\, e^{0.023\times 60} = 500\, e^{1.38} \approx 500 \times 3.975 \approx 1988 \approx \mathbf{2000}$ (nearest 100).

Q56. **Answer: (6)**

Solution

$$\iint_D dA = \int_0^3 \int_0^2 dy\, dx = \int_0^3 2\, dx = [2x]_0^3 = \mathbf{6}.$$

Q57. **Answer: (0.56)**

Solution

Frequency of $A = p = f(\text{AA}) + \frac{1}{2} f(\text{Aa}) = 0.32 + 0.24 = \mathbf{0.56}$.

Q58. **Answer: (30)**

Solution

Ratio $N_2/N_1 = 8 \times 10^5/10^5 = 8 = 2^3$. So 3 doublings occur in 90 min. Generation time $= 90/3 = \mathbf{30}$ min.

Q59. **Answer: (16500)**

Solution

MW $= 150 \times 110\,\text{Da} = \mathbf{16500}\,\text{Da}$ (using average residue mass of 110 Da, which already accounts for water lost in peptide bond formation).

Q60. **Answer: (0.30)**

Solution

$f(ii) = q^2 = 90/1000 = 0.09$. Therefore $q = \sqrt{0.09} = 0.3$. Frequency of i allele $= \mathbf{0.30}$.