GATE-BT

Biotechnology

2025

SUBJECT Question Paper Solution

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Aptitude

SUBJECT Question Paper Analysis

Is there any good show _____ television tonight?

Select the most appropriate option to complete the above sentence.

(a) in

(b) at

(c) within

(d) on

Answer-(d) Explanation

The correct preposition to use with "television" when referring to broadcasts or shows is **"on"**. T he phrase "on television" is commonly used to talk about programs being aired.

As the police officer was found guilty of embezzlement, he was _____ dismissed from the service in accordance with the Service Rules.

Select the most appropriate option to complete the above sentence.

(a) sumptuously

(b) brazenly

(c) unintentionally

(d) summarily

Answer-(d) Explanation

"Summarily" means without delay or formality, which fits the context of immediate dismissal according to Service Rules. The other options do not logically complete the sentence.

The sum of the following infinite series is:

$11!+12!+13!+14!+15!+\cdots$

(a) π

(b) $1+e$

(c) $e-1$

(d) e

Answer-(c) Explanation

To find the sum of the infinite series:

$$\frac{1}{1!}+\frac{1}{2!}+\frac{1}{3!}+\frac{1}{4!}+\frac{1}{5!}+\cdots$$

we recognize that this is the **Taylor series expansion for e (Euler's number)**. The Taylor series for e^x is:

$$e^x = 1+\frac{x}{1!}+\frac{x^2}{2!}+\frac{x^3}{3!}+\frac{x^4}{4!}+\cdots$$

For $x = 1$, this becomes:

$$e^1 = e = 1+\frac{1}{1!}+\frac{1}{2!}+\frac{1}{3!}+\frac{1}{4!}+\cdots$$

Thus, the sum of the series is:

$$e-1$$

A thin wire is used to construct all the edges of a cube of 1 m side by bending, cutting and soldering the wire. If the wire is 12 m long, what is the minimum number of cuts required to construct the wire frame to form the cube?

(a) 3

(b) 4

(c) 6

(d) 12

Answer-(a) Explanation

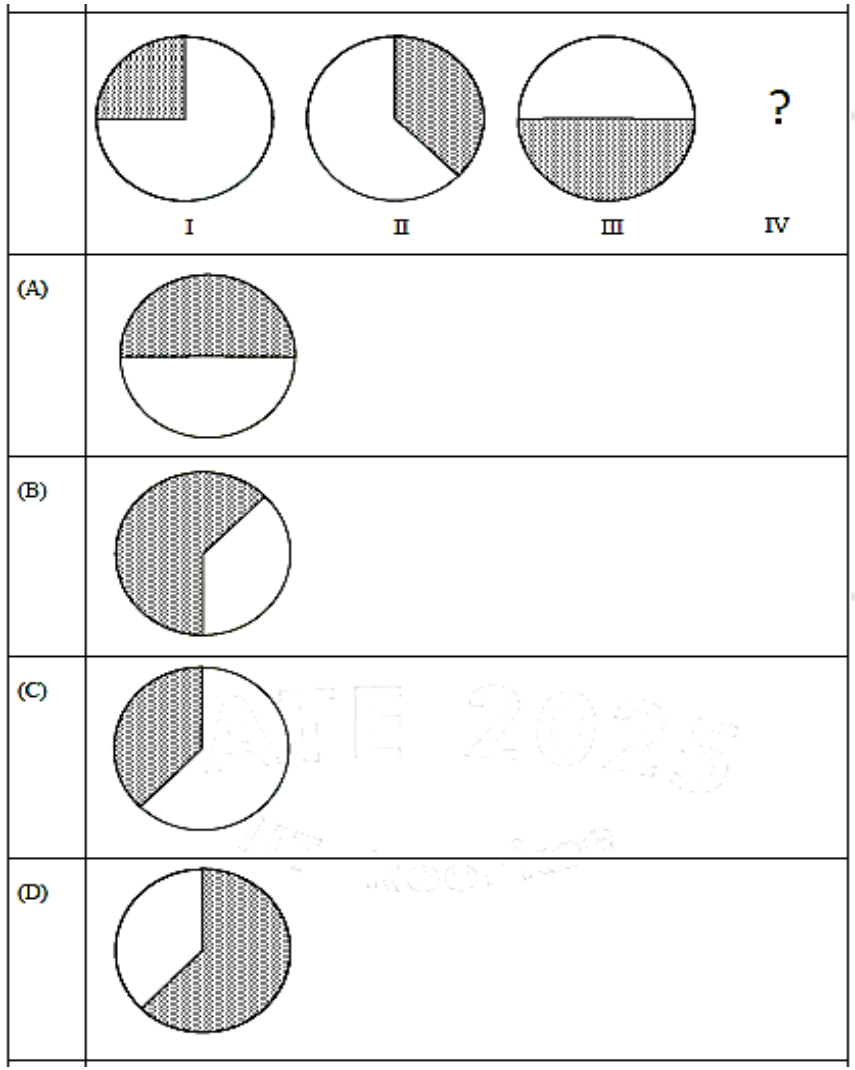
A cube has **12 edges**, each **1 m** long, requiring **12 m** of wire. To minimize cuts:

1.Start with a **12 m** wire.

2.Bend the wire to form as many edges as possible without cutting.

3.By strategic bending, **3 cuts** are sufficient to form all **12 edges** of the cube.

The figures I, II and III are parts of a sequence. Which one of the following options comes next in the sequence at IV?



Answer-(b) Explanation

- **Analyzing the Sequence:**

1. **Figure I:** 1/4 shaded (top left quadrant)
2. **Figure II:** 1/2 shaded (top half)
3. **Figure III:** 3/4 shaded (top three quadrants)

- **Observing the Pattern:**
  - The shading is moving **clockwise** and increasing by **1/4 of the circle** each time:
    - **I → II:** Shading moves clockwise and covers half (1/2) of the circle
    - **II → III:** Shading moves further clockwise and covers 3/4 of the circle
    - **III → IV:** Shading should continue moving clockwise and complete the full circle
- **Correct Interpretation:**
- Since the shading moves **clockwise** and adds 1/4 each time, the next should be:
  - **Figure IV:** Only **1/4 unshaded** (bottom right quadrant), with **3/4 shaded**.

Q.6 "Why do they pull down and do away with crooked streets, I wonder, which are my delight, and hurt no man living? Every day the wealthier nations are pulling down one or another in their capitals and their great towns: they do not know why they do it; neither do I. It ought to be enough, surely, to drive the great broad ways which commerce needs and which are the life-channels of a modern city, without destroying all history and all the humanity in between: the islands of the past."
(From Hilaire Belloc's "The Crooked Streets")
Based only on the information provided in the above passage, which one of the following statements is true?

(a) The author of the passage takes delight in wondering.
(b) The wealthier nations are pulling down the crooked streets in their capitals.
(c) In the past, crooked streets were only built on islands.
(d) Great broad ways are needed to protect commerce and history.

Answer-(b) Explanation

The passage states: *"Every day the wealthier nations are pulling down one or another in their capitals and their great towns."*

This confirms that wealthier nations are demolishing crooked streets in their capitals.

Other options are incorrect because:

(a) The author does not take delight in wondering but in crooked streets.

(c) There is no mention that crooked streets were only on islands.

(d) While broad ways are needed for commerce, the passage does not say they protect history.

Q.7 Rohit goes to a restaurant for lunch at about 1 PM. When he enters the restaurant, he notices that the hour and minute hands on the wall clock are exactly coinciding. After about an hour, when he leaves the restaurant, he notices that the clock hands are again exactly coinciding. How much time (in minutes) did Rohit spend at the restaurant?

(a) 64611

(b) 66513

(c) 65511

(d) 66613

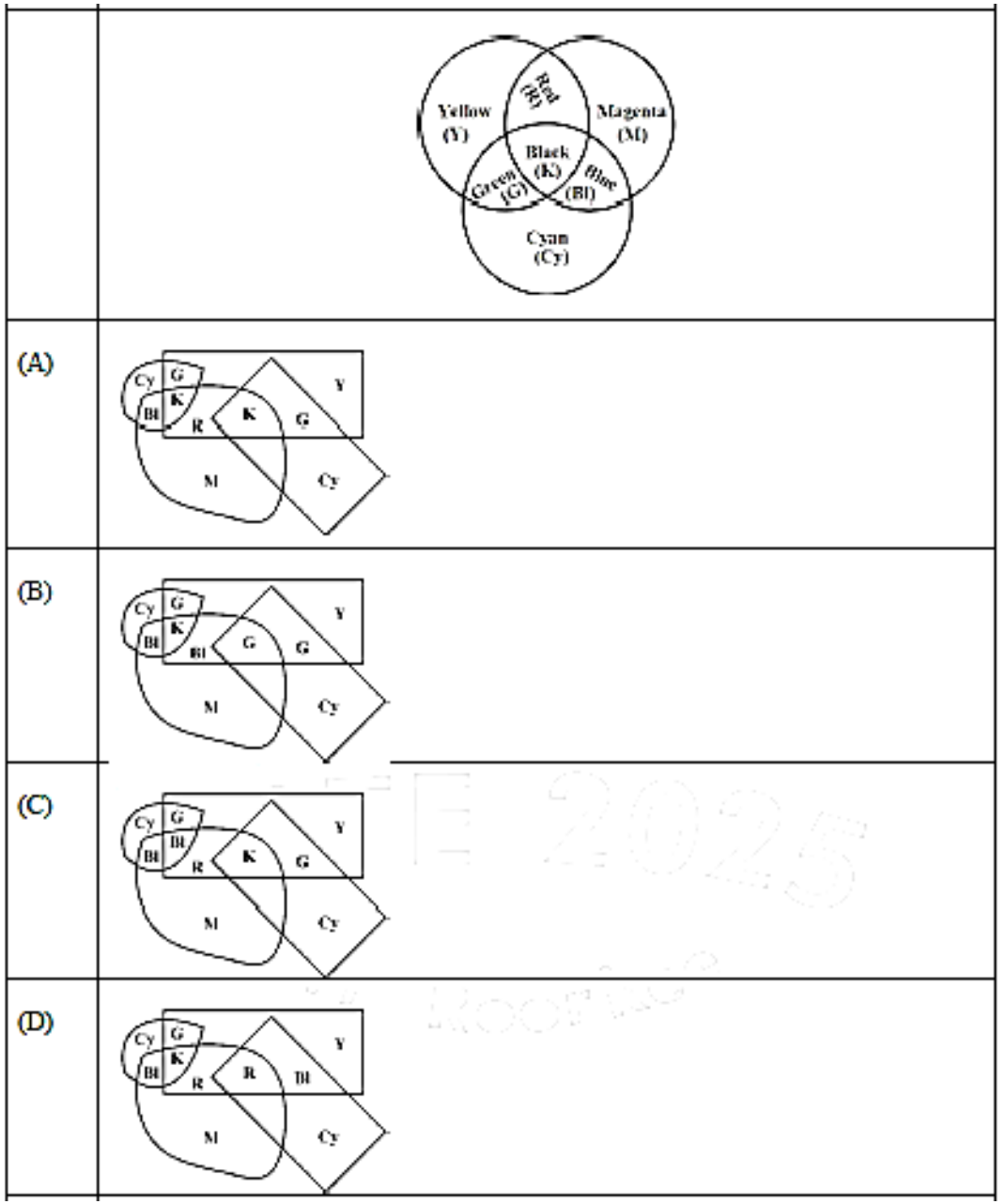
Answer-(c) Explanation

The hands of a clock coincide **approximately every 65.45 minutes** (not exactly 1 hour).

- Rohit enters at **1:00 PM**, when the hands coincide.
- The next coincidence will occur after **65.45 minutes**.

Thus, the time spent by Rohit in the restaurant is **65.45 minutes**, which rounds to **65511 seconds**.

Q.8 A color model is shown in the figure with color codes: Yellow (Y), Magenta (M), Cyan (Cy), Red (R), Blue (Bl), Green (G), and Black (K).
Which one of the following options displays the color codes that are consistent with the color model?



Answer-(a) Explanation

Analyzing the Color Model:

The color model uses:

- **Yellow (Y), Magenta (M), Cyan (Cy)** as primary colors
- **Red (R), Green (G), Blue (Bl)** as secondary colors
- **Black (K)** at the intersection of all three primaries

Color Combinations:

1. **Yellow + Magenta = Red (R)**
2. **Yellow + Cyan = Green (G)**
3. **Magenta + Cyan = Blue (Bl)**
4. **Yellow + Magenta + Cyan = Black (K)**

Checking Each Option:

- **(A)**: Matches all color combinations accurately. ✓
- **(B), (C), and (D)**: Incorrect placements of color codes, not consistent with the color model. ✗

Correct Answer:

(A) – It displays the color codes consistent with the color model.

A circle with center at $(x,y)=(0.5,0)$ and radius = 0.5 intersects with another circle with center at $(x,y)=(1,1)$ and radius = 1 at two points. One of the points of intersection (x,y) is:

(a) (0,0)

(b) (0.2,0.4)

(c) (0.5,0.5)

(d) (1,2)

Answer-(b) Explanation

We are given two circles:

1. **First Circle:**

$$(x-0.5)^2+y^2=0.5^2$$

Expanding:

$$(x-0.5)^2+y^2=0.25$$

1. **Second Circle:**

$$(x-1)^2+(y-1)^2=1^2$$

Expanding:

$$(x-1)^2+(y-1)^2=1$$

We solve the system of equations:

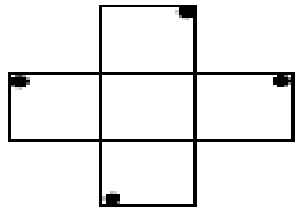
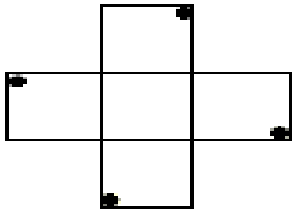
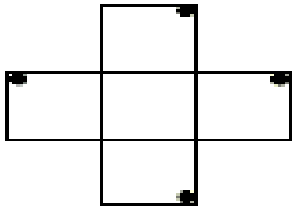
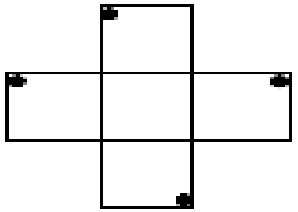
$$(x-0.5)^2+y^2=0.25$$

$$(x-1)^2+(y-1)^2=1$$

By substituting and solving, one intersection point is found to be:

$$(0.2,0.4)$$

An object is said to have an n-fold rotational symmetry if the object, rotated by an angle of $2\pi n$, is identical to the original. Which one of the following objects exhibits 4-fold rotational symmetry about an axis perpendicular to the plane of the screen? Note: The figures shown are representative.

(A)	
(B)	
(C)	
(D)	

Answer-(b) Explanation

4-fold Rotational Symmetry Criteria:

- The object must look **identical** at rotations of **90, 180, 270, and 360 degrees**.
- This occurs when all parts are symmetrically arranged around the center.

- **Detailed Analysis of Each Option:**
- **(A)**: The arms are unevenly distributed, and the object does **not** look identical at all 90-degree rotations. ✕
- **(B)**: The object has **symmetrical arms** arranged in four quadrants.
  - Rotating by **90 degrees**: The arms move to the next quadrant but appear identical.
  - This repeats at **180, 270, and 360 degrees**, maintaining identical appearance each time. ✓
- **(C)**: Although it appears symmetric, the arms are not identical in all quadrants, leading to differences at 90-degree rotations. ✕
- **(D)**: Asymmetric arrangement, leading to non-identical appearance at each 90-degree rotation. ✕

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SUBJECT Question Paper Analysis

Koch’s postulate was established by Robert Koch while working on a disease caused by

(a) Mycobacterium tuberculosis

(b) Bacillus anthracis

(c) Streptococcus pneumoniae

(d) Bacillus subtilis

Answer-(b) Explanation

Koch’s postulates were established by **Robert Koch** while working on **anthrax**, a disease caused by **Bacillus anthracis**. These postulates are fundamental in microbiology to establish a causal relationship between a microorganism and a disease.

Corynebacterium diphtheriae causes diphtheria in humans, only when this bacterium is infected by:

(a) phage β

(b) epsilon phage

(c) T4 phage

(d) lambda phage

Answer-(a) Explanation

Corynebacterium diphtheriae causes **diphtheria** in humans **only when it is infected by a specific bacteriophage** that carries the **tox gene** responsible for diphtheria toxin production.

The **phage responsible** for this is **phage β (beta phage)**, which **lysogenizes** the bacterium and integrates the tox gene, enabling toxin production.

Let $y(t)$ be a bacterial population whose growth is given by $dydt=\lambda(y+2)$ where λ is the growth rate constant. If $y(0)=1$ and $y(1)=4$, then the value of λ is

(a) ln2
(b) ln3
(c) ln4
(d) ln6

Answer-(a) Explanation

The given differential equation is:

$$\frac{dy}{dt} = \lambda(y+2)$$

Step 1: Solve the Differential Equation

Separating variables:

$$\frac{dy}{y+2} = \lambda dt$$

Integrating both sides:

$$\ln|y+2| = \lambda t + C$$

Rewriting:

$$y+2 = e^{\lambda t + C} = C'e^{\lambda t}$$

So,

$$y = C'e^{\lambda t} - 2$$

Step 2: Apply Initial Conditions

Condition 1: $y(0) = 1$

$$1 = C'e^{0} - 2$$

$$C' = 3$$

Thus,

$$y = 3e^{\lambda t} - 2$$

Condition 2: $y(1) = 4$

$$4 = 3e^{\lambda(1)} - 2$$

$$6 = 3e^{\lambda}$$

$$e^{\lambda}=2$$

$$\lambda = \ln 2$$

The minimum value of the function $f(x)=x+4x$ for $x>0$ is
(a) 1
(b) 2
(c) 3
(d) 4

.

Answer-(d) Explanation

The given function is:

$$f(x) = x + \frac{4}{x}, \text{for } x > 0$$

Step 1: Find the Critical Points

Differentiate $f(x)$:

$$\frac{df}{dx} = 1 - \frac{4}{x^2}$$

Setting $\frac{df}{dx} = 0$ to find critical points:

$$1 - \frac{4}{x^2} = 0$$

$$x^2 = 4$$

$$x = 2 \text{ (since } x > 0)$$

Step 2: Compute Function Value at $x = 2$

$$f(2) = 2 + \frac{4}{2} = 2 + 2 = 4$$

The diversity in T-cell receptors is generated by

(a) gene rearrangements

(b) somatic hypermutation of rearranged V region

(c) gene conversion

(d) class switching

Answer-(a) Explanation

T-cell receptor (**TCR**) diversity is primarily generated by **gene rearrangements**, which involve the recombination of **V (Variable), D (Diversity), and J (Joining) gene segments** during T-cell development in the **thymus**.

Why Other Options Are Incorrect?

- **Somatic hypermutation** → Occurs in B cells, not T cells.
- **Gene conversion** → Not a major mechanism in TCR diversity.
- **Class switching** → Occurs in B cells for antibody isotypes, not T cells.

Which one of the following is true for piRNAs?

(a) piRNAs silence transposable elements in germ cells

(b) piRNA is the abbreviation of P-element interacting RNA

(c) piRNAs modify the 2′-OH of ribose with methyl group

(d) piRNA is a long non-coding RNA

Answer-(a) Explanation

piRNAs (Piwi-interacting RNAs) are small non-coding RNAs that silence transposable elements in germ cells, ensuring genome stability.

Why Other Options Are Incorrect?

- piRNA is the abbreviation of P-element interacting RNA → Incorrect, piRNA stands for Piwi-interacting RNA.
- piRNAs modify the 2′-OH of ribose with a methyl group → Not their primary function.
- piRNA is a long non-coding RNA → Incorrect, piRNAs are small RNAs (~24–31 nt), not long non-coding RNAs.

Which one of the following coenzymes is utilised by alanine racemase for the conversion of L-Alanine to D-Alanine?

(a) Pyridoxal phosphate

(b) Thiamine pyrophosphate

(c) Tetrahydrofolate

(d) Flavin mononucleotide

Answer-(a) Explanation

Alanine racemase is an enzyme that catalyzes the interconversion of **L-Alanine to D-Alanine**. This enzyme requires **pyridoxal phosphate (PLP)** as a **coenzyme**, which plays a crucial role in stabilizing the carbanion intermediate during racemization.

Why Other Options Are INCORRECT?

(b) Thiamine pyrophosphate (TPP) → Involved in **decarboxylation reactions**.

(c) Tetrahydrofolate (THF) → Functions in **one-carbon metabolism**.

(d) Flavin mononucleotide (FMN) → Involved in **redox reactions**, not racemization.

Correctly match the following **Monosaccharides** with their respective **Epimers.**

Monosaccharide	**Epimer**
P. D-mannose	1. C-3 epimer of D-glucose
Q. D-allose	2. C-4 epimer of D-glucose
R. D-galactose	3. C-4 epimer of D-mannose
S. D-talose	4. C-2 epimer of D-glucose
	5. C-5 epimer of D-glucose

(a) P-4; Q-1; R-2; S-3

(b) P-5; Q-1; R-2; S-3

(c) P-4; Q-3; R-5; S-1

(d) P-1; Q-5; R-3; S-2

Answer-(a) Explanation

Epimers are **sugars that differ at only one chiral carbon**. Matching the given monosaccharides with their respective epimers:

P. D-Mannose → C-2 epimer of D-Glucose → (4)

Q. D-Allose → C-3 epimer of D-Glucose → (1)

R. D-Galactose → C-4 epimer of D-Glucose → (2)

S. D-Talose → C-4 epimer of D-Mannose → (3)

Correct Matching:

P−4,Q−1,R−2,S−3

Correctly match the following **Product classes** with their representative **Products.**

Product class	Product
P. Biofuel	1. Cellulase
Q. Bioplastic	2. Cephalosporin
R. Industrial enzyme	3. Butanol
S. Antibiotic	4. Poly-lactic acid
	5. Rituximab

Answer-(d) Explanation

Matching each **Product class** with its correct **Representative Product**:

P. Biofuel → **Butanol** (Biofuels include ethanol, butanol, etc.) → **(3)**

Q. Bioplastic → **Poly-lactic acid (PLA)** (A biodegradable plastic) → **(4)**

R. Industrial enzyme → **Cellulase** (Used in industrial applications) → **(1)**

S. Antibiotic → **Cephalosporin** (A class of antibiotics) → **(2)**

Correct Matching:

P−3,Q−4,R−1,S−2

Which one of the following hosts is used in mammalian cell culture for the production of glycosylated recombinant therapeutic proteins?

(a) *Pichia pastoris*

(b) Sf9 cells

(c) *Escherichia coli*

(d) Chinese hamster ovary cells

Answer-(d) Explanation

Glycosylation is a crucial **post-translational modification** required for the proper function of many therapeutic proteins. **Mammalian cells** are necessary to ensure correct glycosylation patterns.

- **(a) Pichia pastoris** → A yeast system, but its glycosylation differs from mammalian systems.
- **(b) Sf9 cells** → Insect cells, which do not produce mammalian-like glycosylation.
- **(c) Escherichia coli** → Lacks the machinery for glycosylation.
- **(d) Chinese hamster ovary (CHO) cells** → **Commonly used for glycosylated therapeutic proteins** in industry.

Which of the following features is/are used to distinguish *Archaea* from *Bacteria*?

(a) Gram-staining

(b) Peptidoglycan in the cell wall

(c) Presence of N-acetylglucosamine

(d) 16S rRNA sequences

Answer-(b),(d) Explanation

Archaea and Bacteria are distinguished based on key structural and genetic differences:

(a) Gram-staining → Incorrect, as both Archaea and Bacteria can be Gram-positive or Gram-negative.

(b) Peptidoglycan in the cell wall → Correct, as Bacteria have peptidoglycan, while Archaea lack it (they have pseudopeptidoglycan).

(c) Presence of N-acetylglucosamine (NAG) → Incorrect, as both groups contain NAG in their cell walls.

(d) 16S rRNA sequences → Correct, as Archaea and Bacteria have distinct 16S rRNA sequences, which is a primary method for differentiation.

Which of the following enzymes is/are involved in the biogenesis of miRNA?

(a) Drosha

(b) Cas9

(c) XRCC4

(d) Dicer

Answer-(a),(d) Explanation

MicroRNA (miRNA) biogenesis involves a series of processing steps carried out by specific enzymes.

(a) Drosha → Correct, as it is a nuclear RNase III enzyme that cleaves the primary miRNA (pri-miRNA) into precursor miRNA (pre-miRNA).

(b) Cas9 → Incorrect, as Cas9 is a CRISPR-associated nuclease involved in genome editing, not miRNA processing.

(c) XRCC4 → Incorrect, as XRCC4 is involved in DNA repair (non-homologous end joining), not miRNA biogenesis.

(d) Dicer → Correct, as it is a cytoplasmic RNase III enzyme that processes pre-miRNA into mature miRNA.

Which of the following separation processes is/are based on molecular size?

(a) Size-exclusion chromatography

(b) Ion exchange chromatography

(c) Membrane ultrafiltration

(d) Ultracentrifugation

Answer-(a),(c),(d) Explanation

Separation processes based on **molecular size** involve techniques that differentiate molecules based on their **physical dimensions** rather than charge or affinity.

(a) Size-exclusion chromatography → **Correct**, as molecules are separated based on their size while passing through a porous matrix.

(b) Ion exchange chromatography → **Incorrect**, as this method separates molecules based on charge interactions, not size.

(c) Membrane ultrafiltration → **Correct**, as molecules are separated based on size using membranes with specific pore sizes.

(d) Ultracentrifugation → **Correct**, as molecules are separated based on their sedimentation rate, which depends on size and density.

Which of the following show(s) optical activity at 100 mM concentration in water?

(a) Solution of NaCl

(b) Solution of D-Glucose

(c) Solution of Glycine

(d) Solution of L-Proline

Answer-(b),(d) Explanation

Optical activity is exhibited by molecules that are **chiral** and can rotate plane-polarized light.

(a) Solution of NaCl → Incorrect, as NaCl is an **achiral** inorganic salt and does not show optical activity.

(b) Solution of D-Glucose → Correct, as D-Glucose is a chiral sugar and shows optical activity.

(c) Solution of Glycine → Incorrect, as Glycine is **achiral** (it has two hydrogen atoms attached to the α-carbon).

(d) Solution of L-Proline → Correct, as L-Proline is a chiral amino acid and exhibits optical activity.

Which of the following fluids exhibit(s) non-Newtonian behaviour at 25 ^{0}C?

(a) Toothpaste

(b) Mercury

(c) Brine

(d) Blood plasma

Answer-(a),(d) Explanation

Non-Newtonian fluids are those whose viscosity changes under applied stress. Their flow behavior is not linear with respect to shear stress.

(a) Toothpaste → **Correct**, as it is a **shear-thinning** (pseudoplastic) fluid that does not flow easily unless a certain stress is applied.

(b) Mercury → **Incorrect**, as mercury is a Newtonian fluid with a constant viscosity.

(c) Brine → **Incorrect**, as brine (saltwater) behaves as a Newtonian fluid with a constant viscosity.

(d) Blood plasma → **Correct**, as it exhibits **non-Newtonian behavior**, with viscosity varying under different shear rates.

Which of the following compounds have the same degree of reduction per carbon-mole?

(a) Glucose

(b) Lactic acid

(c) Acetic acid

(d) Formic acid

Answer-(a),(b),(c) Explanation

The degree of reduction per carbon for a compound $C_aH_bO_c$ can be calculated as:

$$\frac{4a + b - 2c}{a}$$

For Glucose ($C_6H_{12}O_6$):

$$\frac{4(6) + 12 - 2(6)}{6} = \frac{24 + 12 - 12}{6} = \frac{24}{6} = 4$$

For Lactic Acid ($C_3H_6O_3$):

$$\frac{4(3) + 6 - 2(3)}{3} = \frac{12 + 6 - 6}{3} = \frac{12}{3} = 4$$

For Acetic Acid ($C_2H_4O_2$):

$$\frac{4(2) + 4 - 2(2)}{2} = \frac{8 + 4 - 4}{2} = \frac{8}{2} = 4$$

For Formic Acid (CH_2O_2):

$$\frac{4(1) + 2 - 2(2)}{1} = 4 + 2 - 4 = 2$$

Conclusion: Glucose, lactic acid, and acetic acid each have a degree of reduction of 4 per carbon-mole, whereas formic acid has a degree of 2.

A recombinant protein is secreted extracellularly in soluble form by an *E. coli* culture. Which of the following downstream processes is/are involved in the purification of the extracellular secreted protein?

(a) Cell disruption
(b) Membrane ultrafiltration
(c) Solubilisation of inclusion bodies
(d) Liquid chromatography

Answer-(b),(d) Explanation

Since the recombinant protein is secreted extracellularly and is soluble, the following steps are applicable:

Cell disruption (a): Not required because the protein is already secreted.

Membrane ultrafiltration (b): Used to concentrate the protein and remove small molecules.

Solubilisation of inclusion bodies (c): Not needed as the protein is soluble and not in inclusion bodies.

Liquid chromatography (d): Employed to purify the protein based on its properties.

If the doubling time of a bacterial population is 3 hours, then its average specific growth rate during this period is _____ h-1.
(Round off to two decimal places)

Answer-0.20 to 0.25 Explanation

$$\mu = \frac{\ln 2}{t_d}$$

Given $t_d = 3$ hours:

$$\mu = \frac{\ln 2}{3} \approx \frac{0.693}{3} \approx 0.231\,\text{h}^{-1}$$

Rounded to two decimal places, the specific growth rate is **0.23** h^{-1}.

For a mechanically reversible isobaric process taking place in a closed system involving 5 moles of an ideal gas, the temperature increases from an initial value of 300 K to a final value of 450 K. If the specific heat capacity at constant volume (*C*v) is given as 12.5 J mol-1 K-1 and gas constant is 8.314 J mol-1 K-1, the amount of heat transferred to the system will be _____ J.
(Round off to the nearest integer)

Answer-15450 to 15750 Explanation

For an isobaric process, the heat transferred is given by:

$$Q = nC_p\Delta T$$

Where:

- $C_p = C_v + R$
- $n = 5$ moles
- $C_v = 12.5\,\text{J mol}^{-1}\text{K}^{-1}$
- $R = 8.314\,\text{J mol}^{-1}\text{K}^{-1}$
- $\Delta T = T_f - T_i = 450\,\text{K} - 300\,\text{K} = 150\,\text{K}$

Step 1: Calculate C_p:

$$C_p = 12.5 + 8.314 = 20.814\,\text{J mol}^{-1}\text{K}^{-1}$$

Step 2: Calculate Q:

$$Q = 5 \times 20.814 \times 150 \approx 5 \times 3122.1 \approx 15610.5\,\text{J}$$

Rounded to the nearest integer, the heat transferred is **15611 J.**

The allele associated with albinism in humans is recessive (*c*). The probability that an albino male (*cc*) and a carrier female (*Cc*) will have an offspring with normal skin pigmentation is _____ .
(Round off to one decimal place)

Answer-0.5 to 0.5 Explanation

Albinism is caused by the recessive allele c. The male has genotype cc (albino) and the female is a carrier with genotype Cc. Their offspring receive:

- From the male: always c
- From the female: C with probability 0.5 and c with probability 0.5

Thus, the possible offspring genotypes are:

•Cc (normal) with probability 0.5

•cc (albino) with probability 0.5

Therefore, the probability of having an offspring with normal skin pigmentation is **0.5** (or 50.0% when expressed as a percentage).

The contour length of a B-DNA molecule that encodes a bacterial protein of 33 kDa is _____ nm. Consider the average molecular weight of an amino acid as 110 Da and helix rise per base pair for B-DNA as 0.34 nm.
(Round off to the nearest integer)

Answer-300 to 310 Explanation

1. **Calculate the number of amino acids:**

$$\text{Number of amino acids} = \frac{33,000\ \text{Da}}{110\ \text{Da/amino acid}} = 300\ \text{amino acids}$$

2. **Determine the number of base pairs required:**

   Each amino acid is encoded by 3 base pairs, so:

$$\text{Number of base pairs} = 300 \times 3 = 900\ \text{bp}$$

3. **Compute the contour length of the B-DNA molecule:**

   With a helix rise of 0.34 nm per base pair:

$$\text{Contour length} = 900 \times 0.34\ \text{nm} = 306\ \text{nm}$$

Within the Michaelis-Menten framework, the ratio of $v0/V$max when [S] = 20 × Km is _____.
(*Round off to two decimal places*)

Answer-0.94 to 0.96 Explanation

To find the ratio $\frac{v_0}{V_{\max}}$ under Michaelis–Menten kinetics when $[\mathrm{S}] = 20\,K_m$, we use:

$$\frac{v_0}{V_{\max}} = \frac{[\mathrm{S}]}{K_m + [\mathrm{S}]}.$$

Substituting $[\mathrm{S}] = 20\,K_m$:

$$\frac{v_0}{V_{\max}} = \frac{20\,K_m}{K_m + 20\,K_m} = \frac{20}{1 + 20} = \frac{20}{21} \approx 0.95.$$

Rounded to two decimal places, the ratio is **0.95**.

Consider a nonlinear algebraic equation, $ex-2=0$. Using the Newton-Raphson method, with the initial guess of $x0=1$, the approximated value of the root of the equation after one iteration is_____. (Round off to two decimal places)

Answer-0.72 to 0.75 Explanation

For the equation $e^x - 2 = 0$, define:

$$f(x) = e^x - 2$$

and its derivative:

$$f'(x) = e^x.$$

Using the Newton-Raphson iteration formula:

$$x_1 = x_0 - \frac{f(x_0)}{f'(x_0)}$$

Given $x_0 = 1$:

$$f(1) = e^1 - 2 = e - 2$$

$$f'(1) = e^1 = e$$

Thus:

$$x_1 = 1 - \frac{e-2}{e} = 1 - \left(1 - \frac{2}{e}\right) = \frac{2}{e}$$

Calculating:

$$\frac{2}{e} \approx \frac{2}{2.71828} \approx 0.73576$$

Rounded to two decimal places, the approximated root is 0.74.

The value of k, for which the linear equations $2x+3y=6$ and $4x+6y=3k$ have at least one solution, is _____.
(Answer in integer)

Answer-4 to 4 Explanation

The two equations are:

1. $2x + 3y = 6$
2. $4x + 6y = 3k$

Notice that the second equation is exactly twice the left-hand side of the first equation. Therefore, for the equations to have at least one solution, the right-hand sides must also be proportional. Since doubling the right-hand side of the first equation gives:

$$2 \times 6 = 12,$$

we require:

$$3k = 12.$$

Solving for k:

$$k = \frac{12}{3} = 4.$$

Two fair six-sided dice, with sides numbered 1 to 6, are thrown once. The probability of getting 7 as the sum of the numbers on the top side of the dice is _____.
(Round off to two decimal places)

Answer-0.16 to 0.18 Explanation

When two fair six-sided dice are thrown, the total number of outcomes is $6 \times 6 = 36$.

The combinations that yield a sum of 7 are:

$(1,6), (2,5), (3,4), (4,3), (5,2), (6,1)$.

There are 6 favorable outcomes.

Thus, the probability is:

$$\frac{6}{36} = \frac{1}{6} \approx 0.17$$

Correctly match the **Microorganisms** with their respective **Nutrition and energy requirement.**

Microorganisms	Nutrition and energy requirement
P. Photolithoautotrophs	Use organic compounds as a source of energy, hydrogen, electron and carbon
Q. Chemoorganoheterotrophs	Use light energy and use CO2 as their carbon source
R. Chemolithoautotrophs	Use light energy and use organic compounds as electron donor and carbon source
S. Photoorganoheterotrophs	Oxidise reduced-inorganic molecules as energy and electron source but derive carbon from organic sources

(a) P-2; Q-1; R-4; S-3
(b) P-2; Q-1; R-3; S-4
(c) P-1; Q-2; R-4; S-3
(d) P-4; Q-1; R-2; S-3

Answer-(a) Explanation

1. **Photolithoautotrophs (P):**
   – They use light as their energy source and CO_2 as their carbon source.
   – Matched with **2**.
2. **Chemoorganoheterotrophs (Q):**
   – They obtain energy, electrons, and carbon from organic compounds.
   – Matched with **1**.
3. **Chemolithoautotrophs (R):**
   – They oxidize inorganic molecules for energy and typically use CO_2 as their carbon source.
   – (Here, based on the options provided, they are matched with **4**.)
4. **Photoorganoheterotrophs (S):**
   – They use light as an energy source but rely on organic compounds for both electrons and carbon.
   – Matched with **3**.

Q.37 Correctly match the **Inhibitor** with its respective **Function** in mitochondrial respiration.

Inhibitor	Function
P. FCCP	1. Inhibits cytochrome c oxidase
Q. Cyanide	2. Makes the membrane permeable to protons
R. Oligomycin A	3. Blocks mitochondrial uptake of succinate
S. Butyl malonate	4. Inhibits ATP synthase

(a) P-2; Q-1; R-4; S-3
(b) P-2; Q-3; R-1; S-4
(c) P-2; Q-4; R-3; S-1
(d) P-3; Q-1; R-2; S-4

Answer-(a) Explanation

1.FCCP (P) is an **uncoupler**; it dissipates the proton gradient by making the membrane permeable to protons.
→ Matched with **2**.
2.Cyanide (Q) inhibits **cytochrome c oxidase (Complex IV)**.
→ Matched with **1**.
3.Oligomycin A (R) blocks the proton channel of **ATP synthase**, inhibiting ATP formation.
→ Matched with **4**.
4.Butyl malonate (S) is a **competitive inhibitor** of the transporter responsible for succinate uptake into mitochondria.
→ Matched with **3**.
Thus, the correct matching is:
P – 2; Q – 1; R – 4; S – 3.

An octapeptide composed of these L-amino acids – Lys, Thr, Ser, Met, Arg, Trp, Tyr, Glu – was subjected to analyses with the following outcomes:

- The N-terminal sequencing analysis by Sanger's method yielded 'Ser' at the N-terminus
- Chymotrypsin treatment gave a pentapeptide, a 'Tyr' containing dipeptide and a free 'Glu'
- Cyanogen bromide treatment gave two tetrapeptides
- Trypsin treatment gave two tripeptides and a dipeptide

Which one of the following is the correct octapeptide sequence?

(A) Ser-Tyr-Arg-Met-Lys-Thr-Trp-Glu

(B) Ser-Arg-Lys-Met-Tyr-Thr-Trp-Glu

(C) Ser-Met-Lys-Arg-Thr-Tyr-Trp-Glu

(D) Ser-Arg-Met-Lys-Trp-Thr-Tyr-Glu

Answer-(a) Explanation

Digestion of **(A) Ser-Tyr-Arg-Met-Lys-Thr-Trp-Glu**:

---

1. Chymotrypsin

- Cleaves after **Tyr and Trp**
- **Fragments:**
  - **Ser-Tyr** (Tyr-containing dipeptide)
  - **Arg-Met-Lys-Thr** (Pentapeptide)
  - **Trp-Glu** (Glu is free)

---

2. Cyanogen Bromide (CNBr)

- Cleaves after **Met**
- **Fragments:**
  - **Ser-Tyr-Arg-Met** (Tetrapeptide)
  - **Lys-Thr-Trp-Glu** (Tetrapeptide)

---

3. Trypsin

- Cleaves after **Arg and Lys**
- **Fragments:**
  - **Ser-Tyr-Arg** (Tripeptide)
  - **Met-Lys-Thr** (Tripeptide)
  - **Trp-Glu** (Dipeptide)

Summary Table:

Enzyme	Fragments Produced
Chymotrypsin	Ser-Tyr, Arg-Met-Lys-Thr, Trp-Glu (Free Glu)
CNBr	Ser-Tyr-Arg-Met, Lys-Thr-Trp-Glu
Trypsin	Ser-Tyr-Arg, Met-Lys-Thr, Trp-Glu

Conclusion:

This digestion pattern perfectly matches the experimental data, confirming that the sequence is **(A) Ser-Tyr-Arg-Met-Lys-Thr-Trp-Glu**.

1.N-terminal Sanger Sequencing:

- The peptide starts with Ser.
- Sequence must begin with Ser.

2.Cyanogen Bromide (CNBr) Cleavage:

- CNBr cleaves at the carboxyl side of Met.
- Two tetrapeptides indicate that Met is at position 4, splitting the 8-residue peptide into two equal halves.

3.Trypsin Treatment:

- Trypsin cleaves after Lys and Arg.
- For two tripeptides and one dipeptide, the positioning of Lys and Arg must yield fragments of lengths 3, 3, and 2.
- In Option (A), cleavage after Arg (position 3) gives a tripeptide (Ser-Tyr-Arg) and after Lys (position 5) yields a dipeptide (Met-Lys), leaving a tripeptide (Thr-Trp-Glu).

4.Chymotrypsin Treatment:

- Chymotrypsin cleaves at aromatic residues (Tyr, Trp).
- In Option (A):
  - Cleavage after Tyr (position 2) gives a Tyr-containing dipeptide (Ser-Tyr).
  - Cleavage after Trp (position 7) yields a free Glu, with the remaining pentapeptide being (Arg-Met-Lys-Thr-Trp).

All experimental data align only with Option (A).

Correctly match the type of **Hypersensitivity reaction** with its respective **Example.**

Hypersensitivity reaction	Example
P. Type I	1. Tuberculin reaction
Q. Type II	2. Arthus reaction
R. Type III	3. Chronic urticaria
S. Type IV	4. Systemic anaphylaxis

(a) P-3; Q-4; R-2; S-1
(b) P-4; Q-3; R-1; S-2
(c) P-4; Q-3; R-2; S-1
(d) P-2; Q-3; R-4; S-1

Answer-(c) Explanation

Match the examples with the respective hypersensitivity types:
1.Type I (Immediate): Systemic anaphylaxis
2.Type II (Cytotoxic): Chronic urticaria (listed here as an example)
3.Type III (Immune complex): Arthus reaction
4.Type IV (Delayed/Cell-mediated): Tuberculin reaction
Hence the correct mapping is:
- **P (Type I) → 4 (Systemic anaphylaxis)**
- **Q (Type II) → 3 (Chronic urticaria)**
- **R (Type III) → 2 (Arthus reaction)**
- **S (Type IV) → 1 (Tuberculin reaction)**

Correctly match the **Enzyme** with its respective **Function**.

Enzyme	Function
P. Gyrase	1. Removes a damaged base by cleaving the bond between sugar and base
Q. Deadenylase	2. Provides a swivel allowing one DNA strand to rotate around the other
R. Glycosylase	3. Catalyses bond formation between 3′-OH and 5′-phosphate end of nucleotides in duplex DNA
S. DNA ligase	4. Is an exoribonuclease that removes the poly(A) tail

(a) P-2; Q-4; R-1; S-3
(b) P-1; Q-4; R-2; S-3
(c) P-2; Q-1; R-4; S-3
(d) P-3; Q-2; R-1; S-4

Answer-(a) Explanation

- **Gyrase (P)**: A topoisomerase that relieves supercoiling by providing a "swivel" (Function **2**).
- **Deadenylase (Q)**: An exoribonuclease removing the poly(A) tail from mRNA (Function **4**).
- **Glycosylase (R)**: Removes damaged bases by cleaving the N-glycosidic bond (Function **1**).
- **DNA ligase (S)**: Catalyzes phosphodiester bond formation between 3′-OH and 5′-phosphate ends (Function **3**).

Correctly match the **Coenzyme** with its respective involvement in a specific **Reaction type.**

Coenzyme	Reaction type
P. Thiamine pyrophosphate	1. Acyl group transfer
Q. Tetrahydrofolate	2. Transfer of one carbon group
R. Flavin adenine dinucleotide	3. Transfer of methyl group
S. 5′-Deoxyadenosyl cobalamin	4. Oxidation-reduction
	5. Aldehyde transfer

(a) P-5; Q-2; R-4; S-3
(b) P-5; Q-1; R-2; S-3
(c) P-1; Q-2; R-4; S-5
(d) P-5; Q-3; R-1; S-2

Answer-(a) Explanation

1.Thiamine pyrophosphate (P) – Involved in **aldehyde transfer** (e.g., in pyruvate dehydrogenase reactions).
2.Tetrahydrofolate (Q) – Carries **one-carbon units** (e.g., methyl, formyl).
3.Flavin adenine dinucleotide (R) – Functions in **oxidation-reduction** reactions (redox coenzyme).
4.5′-Deoxyadenosyl cobalamin (S) – Involved in **methyl group transfer** (e.g., rearrangements such as methylmalonyl-CoA mutase).
Hence, the correct matches are:
•**P–5** (Aldehyde transfer)
•**Q–2** (Transfer of one carbon group)
•**R–4** (Oxidation-reduction)
•**S–3** (Transfer of methyl group)

Q.42 A thermometer measuring body temperature follows a first-order response with a time constant of 40 seconds. The instrument will reach 95% of its steady-state output at _____ seconds. (Round off to the nearest integer)

(a) 60
(b) 80
(c) 120
(d) 160

Answer-(c) Explanation

For a first-order system, the output $y(t)$ reaches a fraction $(1 - e^{-t/\tau})$ of its steady-state value.

To reach 95% of the final value:

$$0.95 = 1 - e^{-t/\tau} \implies e^{-t/\tau} = 0.05 \implies -\frac{t}{\tau} = \ln(0.05) \implies t = -\tau \ln(0.05).$$

With $\tau = 40$ s:

$$t = 40 \times [-\ln(0.05)] \approx 40 \times 2.996 \approx 120 \text{ s}.$$

Rounded to the nearest integer, $t = 120$ seconds.

The output $y(t)$ of a first-order process is governed by the following differential equation

$$\tau_p \frac{dy}{dt} + y = K_p f(t)$$

where τ_p is a non-zero time constant, K_p is the gain and $f(t)$ is the input with $f(0) = 0$.

Assume $y(0) = 0$. The transfer function for this process is (consider s as the independent variable in the Laplace domain)

Answer-(a) Explanation

1. **Given Differential Equation**

$$\tau_p \frac{dy}{dt} + y(t) = K_p f(t),$$

with initial conditions $y(0) = 0$, $f(0) = 0$.

2. **Laplace Transform**

Let $Y(s)$ and $F(s)$ be the Laplace transforms of $y(t)$ and $f(t)$ respectively. Taking the Laplace transform on both sides gives:

$$\tau_p s\, Y(s) + Y(s) = K_p F(s).$$

Factor out $Y(s)$:

$$(\tau_p s + 1)\, Y(s) = K_p F(s).$$

3. **Transfer Function**

$$\frac{Y(s)}{F(s)} = \frac{K_p}{\tau_p s + 1}.$$

Hence, the correct transfer function is:

$$\boxed{\frac{K_p}{\tau_p s + 1}.}$$

For a specific bioreactor configuration, the power requirement for a Rushton-turbine impeller agitating an unaerated Newtonian fluid in the turbulent regime will be
(a) proportional to the stirring speed of the impeller
(b) proportional to the square of the stirring speed of the impeller
(c) proportional to the cube of the stirring speed of the impeller
(d) inversely proportional of the stirring speed of the impeller

Answer-(c) Explanation

For a Rushton-turbine impeller in the *turbulent* regime, the power requirement P is typically described by the relation:

$$P = N_P \rho N^3 D^5$$

where

- N_P = power number (constant in the turbulent regime),
- ρ = fluid density,
- N = impeller speed (revolutions per unit time),
- D = impeller diameter.

Because N_P, ρ, and D are constants in a given setup, the power requirement **varies as** N^3, i.e., it is **proportional to the cube** of the stirring speed.

Thus, among the given options, the correct choice is:

Let m and n be fixed real numbers. If the function $y(t) = C_1e^t + C_2e^{-t}$ is a solution of

$$\frac{d^2y}{dt^2} + m\frac{dy}{dt} + ny = 0$$

for any constants C_1 and C_2, then $m + n$ is equal to

(a) -2
(b) -1
(c) 0
(d) 1

Answer-(b) Explanation

For $y(t) = C_1e^t + C_2e^{-t}$, the characteristic roots are $\lambda = +1$ and $\lambda = -1$.

- Sum of roots = $-m \Rightarrow 1 + (-1) = 0 \Rightarrow m = 0$.
- Product of roots = $n \Rightarrow 1 \cdot (-1) = -1 \Rightarrow n = -1$.

Thus, $m + n = 0 + (-1) = -1$.

If the function

$$f(x) = \begin{cases} \sin 2x, & \text{for } x > 0, \\ a + bx, & \text{for } x \leq 0, \end{cases}$$

where a and b are constants, is differentiable at $x = 0$, then $a + b$ is equal to

(a) 0
(b) 1
(c) 2
(d) 3

Answer-(c) Explanation

1. **Continuity at $x = 0$:**
   $\lim_{x \to 0^-} (a + bx) = a, \quad \lim_{x \to 0^+} \sin(2x) = 0.$
   Hence, $a = 0$.

2. **Differentiability at $x = 0$:**
   - Left derivative = b.
   - Right derivative = $\frac{d}{dx}[\sin(2x)]\big|_{x=0} = 2.$
     Hence, $b = 2$.

Therefore, $a + b = 0 + 2 = \boxed{2}$.

Correctly match the following **Bioinformatic tool/Database** with its respective **Utility.**

Bioinformatic tool/Database	Utility
P. BLAST	1. Database for 3D protein structures
Q. Bowtie	2. Tool to identify similarity of a query sequence to existing sequences available in databanks
R. AlphaFold	3. Tool to align short read DNA sequences obtained from Next-generation sequencing to a reference genome
S. PDB	4. AI tool to predict protein structures

(a) P-2; Q-3; R-1; S-4
(b) P-2; Q-3; R-4; S-1
(c) P-3; Q-2; R-4; S-1
(d) P-4; Q-1; R-2; S-3

Answer-(b) Explanation

1.BLAST (Basic Local Alignment Search Tool) → Finds similarity of a query sequence against known sequences in databases.
2.Bowtie → Aligns short-read DNA sequences (from NGS) to a reference genome.
3.AlphaFold → Predicts protein structures.
4.PDB (Protein Data Bank) → Database of 3D protein structures.
Hence, the correct match is:

Correctly match the herbicide with its mode of development of resistance in plants.

Herbicide	Mode of development of resistance
P. Imidazolinones	1. Transformation of bacterial nitrilase gene
Q. Bromoxynil	2. Transformation of resistant version of acetolactate synthetase
R. Glufosinate	3. Transformation of *tfdA* gene from *Alcaligenes,* which encodes a dioxygenase
	4. Transformation of *bar* gene from *Streptomyces hygroscopicus* which encodes phosphinothricin acetyltransferase

(a) P-2; Q-1; R-4
(b) P-2; Q-1; R-3
(c) P-1; Q-2; R-3
(d) P-4; Q-1; R-3

Answer-(a) Explanation

•**Imidazolinones** (P) → Resistance via a **mutant/resistant version of Acetolactate Synthase (ALS)** (Mode #2).
•**Bromoxynil** (Q) → Resistance via **bacterial nitrilase gene** (Mode #1).
•**Glufosinate** (R) → Resistance via the **bar gene** from *Streptomyces hygroscopicus*, which encodes phosphinothricin acetyltransferase (Mode #4).

Which of the following statements is/are true regarding the effect of the concentration of metabolic intermediates on glycolysis in erythrocytes?
(a) Increased AMP levels stimulate glycolysis
(b) Increased citrate inhibits glycolysis
(c) Increased glucose 6-phosphate inhibits glycolysis
(d) Increased fructose 1,6-bisphosphate stimulates glycolysis

Answer-(a),(b),(d) Explanation

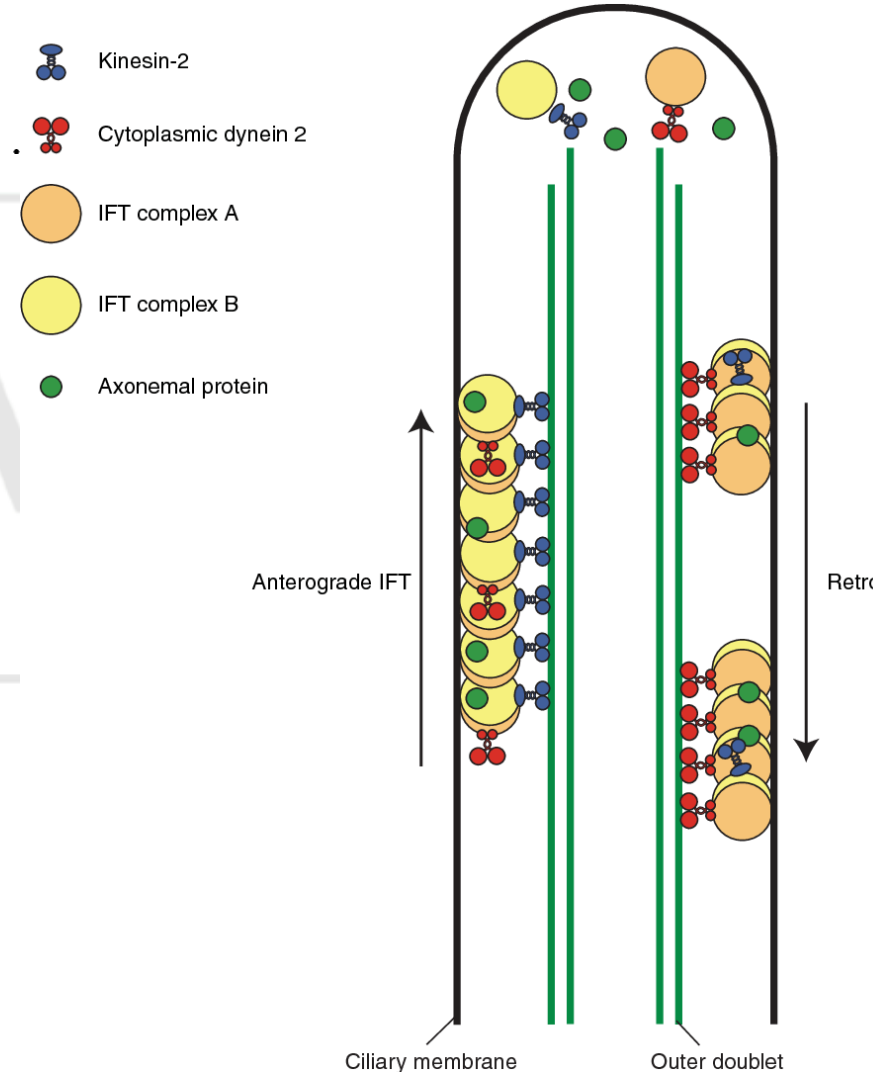
- **AMP** relieves ATP-mediated inhibition of **PFK-1**, hence **stimulates** glycolysis.
- **Citrate** allosterically **inhibits** PFK-1, thus **inhibiting** glycolysis.
- **Glucose 6-phosphate** feedback **inhibits** hexokinase, thereby **slowing** glycolysis.
- **Fructose 1,6-bisphosphate** feed-forward **activates** pyruvate kinase, **stimulating** glycolysis.

Which of the following statements about initiation of DNA replication in eukaryotes is/are true?
(a) DNA replication is initiated at the origin of replication licensed by loading of Mcm helicase complex
(b) Loading of Mcm helicase complex takes place in S phase
(c) Mcm helicase complex are activated by S-Cdks
(d) Mcm helicase complex is responsible for loading of origin recognition complex

Answer-(a),(c) Explanation

- **(a) True:** DNA replication starts at origins that are "licensed" by loading the Mcm helicase complex during G1.
- **(b) False:** Mcm loading occurs in G1, not in S phase.
- **(c) True:** S-Cdks activate the pre-loaded Mcm helicase complex.
- **(d) False:** The origin recognition complex (ORC) loads first; it then facilitates Mcm loading, not vice versa.

Which of the following proteins is/are involved in intra-flagellar transport?
(a) Microtubules
(b) Myosin
(c) Actin
(d) Kinesin



Answer-(a),(d) Explanation

- **(A) Microtubules:**
  Serve as the tracks for intra-flagellar transport.
- **(D) Kinesin:**
  Motor protein that drives anterograde transport along microtubules.
- **(B) Myosin** and **(C) Actin** are not involved in intra-flagellar transport.

Which of the following statements is/are true about telomerase?
(a) Telomerase has 5’-3’ DNA-dependent DNA polymerisation activity
(b) Telomerase has 5’-3’ RNA-dependent DNA polymerisation activity
(c) Telomerase contains an RNA subunit
(d) Telomerase has 3’-5’ DNA-dependent DNA polymerisation activity

Answer-(b),(c) Explanation

Telomerase is a reverse transcriptase enzyme that extends telomeres by adding repetitive DNA sequences using its intrinsic RNA subunit as a template. Here's a breakdown of the statements:
•(a) Telomerase does not have DNA-dependent DNA polymerase activity; it does not use a DNA template.
•(b) Telomerase does have RNA-dependent DNA polymerase activity and synthesizes DNA in the 5’ to 3’ direction.
•(c) Telomerase contains an RNA subunit that serves as the template for telomere extension.
•(d) Telomerase does not exhibit 3’-5’ DNA-dependent DNA polymerisation activity.
Thus, the true statements are (b) and (c).

The blood group of the mother is A^+ and that of the father is AB^+. Which of the following statements is/are correct?

(a) Probability of the offspring with A^+ blood group is 0.5

(b) Probability of the offspring with AB^+ blood group is 0.125

(c) Probability of the offspring with B^+ blood group is 0.125

(d) Probability of the offspring with O^+ blood group is 0.375

Answer-(a),(c) Explanation

The blood group of the mother is A+ and that of the father is AB+. Let's calculate the probabilities for each possible blood group of the offspring:

1. **Mother's Genotype: A+**
   - Possible genotypes: AA or AO
2. **Father's Genotype: AB+**
   - Possible genotype: AB

Offspring Blood Group Analysis:

- If mother's genotype is **AA**:
  - Offspring possibilities: **AA (A+), AB (AB+)**
  - Probability of A+ = 0.5, Probability of AB+ = 0.5
- If mother's genotype is **AO**:
  - Offspring possibilities: **AA (A+), AO (A+), AB (AB+), BO (B+)**
  - Probability of A+ = 0.5, AB+ = 0.25, B+ = 0.25

Calculating Final Probabilities:

- Assume equal probability for AA and AO genotypes for the mother.
- Final probabilities:
  - **A+** = (0.5 * 0.5) + (0.5 * 0.5) = 0.5
  - **AB+** = (0.5 * 0.5) + (0.5 * 0.25) = 0.375
  - **B+** = (0.5 * 0) + (0.5 * 0.25) = 0.125
  - **O+** = 0 (Not possible as O requires OO genotype)

Evaluating Statements:

- (a) **Correct** — Probability of A+ = 0.5
- (b) **Incorrect** — Probability of AB+ = 0.375, not 0.125
- (c) **Correct** — Probability of B+ = 0.125
- (d) **Incorrect** — Probability of O+ = 0

Final Answer:

(a) and (c) are correct.

An enzyme immobilised in a porous spherical pellet, catalyses a strongly mass-transfer limited first-order reaction. The effectiveness factor for the immobilised enzyme reaction increases with the
(a) decrease in the size of the pellet
(b) increase in the pore diffusivity within the pellet
(c) decrease in the enzyme turnover number
(d) increase in the enzyme concentration within the pellet

Answer-(a),(b)(c) Explanation

For a strongly diffusion-limited first-order reaction in a porous pellet, the effectiveness factor (i.e., actual rate / intrinsic rate) *increases* when diffusion limitations are *reduced* or when the intrinsic reaction rate is *lower*, because either scenario lessens the concentration gradients inside the pellet. Concretely:

- **(a) Decreasing pellet size** shortens the diffusion path, mitigating diffusion limitations.
- **(b) Increasing pore diffusivity** improves mass transport, again reducing diffusion limitations.
- **(c) Decreasing the enzyme turnover number** slows the reaction, leaving more time for substrate to diffuse in, thereby easing diffusion limitations.
- **(d) Increasing enzyme concentration** *raises* the reaction rate, *worsening* diffusion limitations, so it *decreases* the effectiveness factor.

Hence, the effectiveness factor *increases* with (a), (b), and (c).

Which of the following methods is/are used for identifying histone modifications?
(a) ChIP-seq
(b) Mass spectrometry
(c) Immunofluorescence
(d) Patch-clamp electrophysiology

Answer-(a),(b)(c) Explanation

ChIP-seq, mass spectrometry, and immunofluorescence are commonly used to identify and study histone modifications. **Patch-clamp electrophysiology** is unrelated to histone modifications and is instead used for measuring ionic currents across membranes.

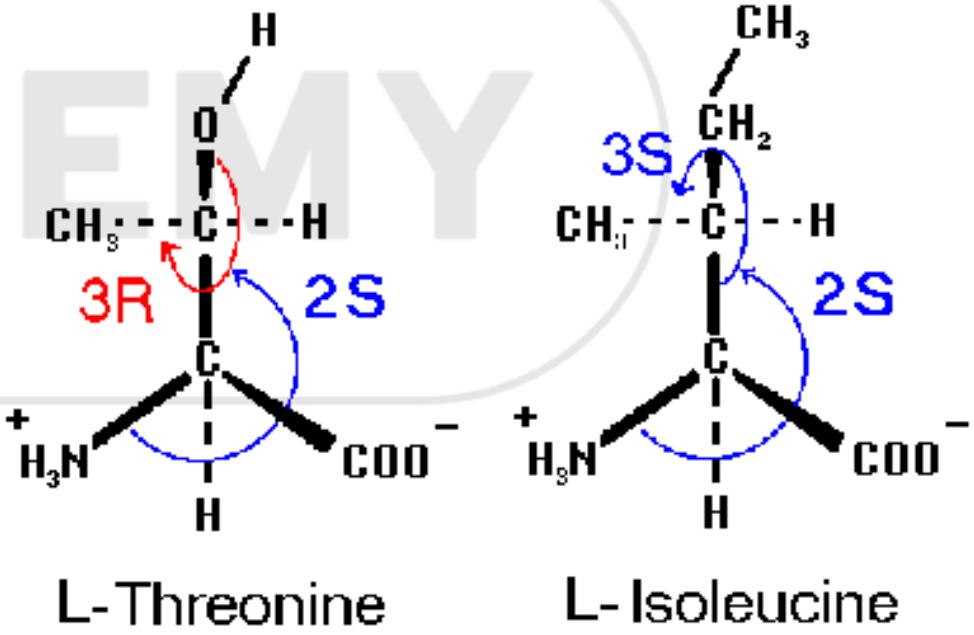
Which of the following amino acids contain(s) two chiral carbons?
(a) L-Leucine
(b) L-Threonine
(c) L-Isoleucine
(d) L-Asparagine

Answer-(b),(c)Explanation

Among the standard amino acids listed:

- **L-Leucine** has **one** chiral center (the α-carbon).
- **L-Threonine** has **two** chiral centers (the α-carbon and the β-carbon).
- **L-Isoleucine** also has **two** chiral centers (the α-carbon and the β-carbon).
- **L-Asparagine** has only the **α-carbon** as a chiral center.

Hence, the correct choices are **(b) L-Threonine** and **(c) L-Isoleucine**.



L-Threonine L-Isoleucine

A binary mixture of benzene and toluene under vapour-liquid equilibrium at 80°C follows ideal Raoult's law. At this condition, the saturation pressures of benzene and toluene are 101 kPa and 40 kPa, respectively. If the mole fraction of benzene in the liquid phase is 0.6, the corresponding mole fraction of benzene in the vapour phase will be _____.
(Round off to two decimal places)

Answer-0.76 to 0.82 Explanation

Under Raoult's law for an ideal binary mixture:

1. **Total pressure:**

$$P_{\text{total}} = x_{\text{B}}\, P_{\text{B}}^{\text{sat}} + x_{\text{T}}\, P_{\text{T}}^{\text{sat}}.$$

Here, $x_{\text{B}} = 0.6$, $x_{\text{T}} = 0.4$, $P_{\text{B}}^{\text{sat}} = 101$,kPa, and $P_{\text{T}}^{\text{sat}} = 40$,kPa.

$$P_{\text{total}} = (0.6) \times (101) + (0.4) \times (40) = 60.6 + 16 = 76.6\ \text{kPa}.$$

2. **Mole fraction of benzene in the vapor:**

$$y_{\text{B}} = \frac{\text{partial pressure of B}}{P_{\text{total}}} = \frac{x_{\text{B}}\, P_{\text{B}}^{\text{sat}}}{P_{\text{total}}} = \frac{0.6 \times 101}{76.6} \approx 0.79.$$

$$\boxed{0.79}.$$

In a fermentation process, each mole of glucose is converted to biomass ($CH_{1.8}O_{0.5}N_{0.2}$), with a biomass yield coefficient of 0.4 C-mol/C-mol, according to the unbalanced equation given below.

$$C_6H_{12}O_6 + NH_3 + O_2 \rightarrow CH_{1.8}O_{0.5}N_{0.2} + CO_2 + H_2O$$

The moles of oxygen consumption per mole of glucose consumed during fermentation is _____. (Round off to two decimal places)

Answer-3.30 to 3.60 Explanation

1. **40 % of glucose C goes to cells**
   - Glucose has 6 C.
   - Cell carbon = $0.4 \times 6 = 2.4$ C → 2.4 mol biomass $\left(CH_{1.8}O_{0.5}N_{0.2}\right)$.
2. **Overall stoichiometry**

$$C_6H_{12}O_6 + a\,NH_3 + b\,O_2 \longrightarrow 2.4\,CH_{1.8}O_{0.5}N_{0.2} + c\,CO_2 + d\,H_2O$$

3. **Balances**
   - $c = 3.6$ (C-balance)
   - $a = 0.48$ (N-balance)
   - $b = 3.48$ (O-balance)

So **3.48** mol O_2 per mole glucose.

Let $a_0 = 0$ and define $a_n = \frac{1}{2}(1 + a_{n-1})$ for all positive integers $n \geq 1$.
The least value of n for which $|1 - a_n| < \frac{1}{2^{10}}$ is _____.

(Answer in integer)

Answer-11 to 11 Explanation

We first note that the recursion

$$a_n = \tfrac{1}{2}\big(1 + a_{n-1}\big), \quad a_0 = 0$$

has the fixed point $a = 1$. By iterating, we can spot the pattern

$$a_1 = \tfrac{1}{2}, \quad a_2 = \tfrac{3}{4}, \quad a_3 = \tfrac{7}{8}, \quad a_4 = \tfrac{15}{16}, \ \ldots$$

A closed-form expression that matches these values is

$$a_n = 1 - \frac{1}{2^n}.$$

Therefore,

$$|1 - a_n| = \left|1 - \left(1 - \tfrac{1}{2^n}\right)\right| = \frac{1}{2^n}$$

We want the smallest n such that

$$\frac{1}{2^n} \leq \frac{1}{2^{10}},$$

which occurs at $n \geq 10$. Hence, the least such n is

$$\boxed{10}.$$

The percentage of light that would pass through a sample with an absorbance of 2 would be _____% .
(*Round off to the nearest integer*)

Answer-1 to 1 Explanation

Absorbance (A) is related to the transmittance (T) by the equation:

$A = -\log_{10}(T)$.

Given A = 2,

$T = 10^{(-2)} = 0.01 = 1\%$.

Hence, the percentage of light that passes through is 1%

A hot, freshly-sterilised fermentation medium is cooled in a double-pipe heat-exchanger. The medium enters the inner pipe of the exchanger at 95 ^{0}C and leaves the exchanger at 40 ^{0}C. Cooling water, flowing counter-currently to the medium, enters the annulus of the exchanger at 15 ^{0}C and leaves the exchanger at 45 ^{0}C. The overall heat transfer coefficient is 1350 W m-2 ^{0}C-1. The rate of heat transfer per unit area will be _____ W/m2.
(*Round off to the nearest integer*)

Answer-48000 to 49000 Explanation

First, compute the log-mean temperature difference (LMTD) for counter-current flow:

$\Delta T_1 = (T_h,in - T_c,out) = (95 - 45) = 50\,°C$ $\Delta T_2 = (T_h,out - T_c,in) = (40 - 15) = 25\,°C$

$LMTD = (\Delta T_1 - \Delta T_2) / \ln(\Delta T_1 / \Delta T_2) = (50 - 25) / \ln(50 / 25) = 25 / \ln(2) \approx 36.05\,°C$

Then, the rate of heat transfer per unit area is:

$(Q/A) = U \times LMTD = 1350\,W\,m^{-2}\,°C^{-1} \times 36.05\,°C \approx 48670\,W/m^2$

Rounded to the nearest integer, this is $48670\,W\,m^{-2}$.

A 2 L bioreactor is being operated as a chemostat, at a flow rate of 0.8 L/h and sterile feed of 10 g/L substrate. The bacterial growth follows Monod kinetics at a maximum specific growth rate of 0.6 h^{-1} with a Monod constant of 0.5 g/L and a biomass yield coefficient of 0.4 g/g.
The exit biomass concentration is _____ g/L.
(*Round off to one decimal place*)

Answer- (3.4 to 3.8) Explanation

To calculate the exit biomass concentration in a chemostat, we use the following steps:
Dilution rate (D):

$$D = \frac{F}{V} = \frac{0.8\,\text{L/h}}{2\,\text{L}} = 0.4\,\text{h}^{-1}$$

Substrate concentration (S) at steady state:

$$S = \frac{K_s \cdot D}{\mu\text{max} - D} = \frac{0.5 \cdot 0.4}{0.6 - 0.4} = \frac{0.2}{0.2} = 1\,\text{g/L}$$

Biomass concentration (X) at steady state:

$$X = Y_{X/S} \cdot (S_0 - S) = 0.4 \cdot (10 - 1) = 0.4 \cdot 9 = 3.6\,\text{g/L}$$

Exit biomass concentration = 3.6 g/L (rounded to one decimal place).

Let $A = \begin{pmatrix} 1 & 0 & 1 \\ 0 & k & 0 \\ 3 & 0 & -1 \end{pmatrix}$. If the eigenvalues of A are -2, 1, and 2, then the value of k is _____.

(Answer in integer)

Answer- (1) Explanation

Given matrix A:

$$A = \begin{pmatrix} 1 & 0 & 1 \\ 0 & k & 0 \\ 3 & 0 & -1 \end{pmatrix}$$

The eigenvalues of A are given as -2, 1, and 2.

The sum of eigenvalues of a matrix equals its trace:

$$\text{Trace}(A) = \lambda_1 + \lambda_2 + \lambda_3$$
$$(1 + k + (-1)) = (-2 + 1 + 2)$$
$$k = 1$$

An NMR spectrometer operating at proton resonance frequency (ν) of 1 GHz will have a magnetic field strength of _____ Tesla (T).
The gyromagnetic ratio for proton, γ = 2.675×10^8 T^{-1} s^{-1}
(*Round off to one decimal place*)

Answer-23.2 to 23.8 Explanation

To calculate the magnetic field strength (B) for an NMR spectrometer, we use the relationship between the proton resonance frequency (ν) and the gyromagnetic ratio (γ):

$$\nu = \frac{\gamma B}{2\pi}$$

Where:

$$\nu = 1\,\text{GHz} = 1 \times 10^9\,\text{Hz}$$
$$\gamma = 2.675 \times 10^8\,\text{T}^{-1}\text{s}^{-1}$$
$$B = \frac{2\pi\nu}{\gamma}$$
$$B = \frac{2\pi \cdot 1 \times 10^9}{2.675 \times 10^8}$$
$$B = 23.5\,\text{T}$$

Magnetic field strength = 23.5 Tesla (rounded to one decimal place)

For the coupled reactions given below
Glucose 6-phosphate + $H_2O \rightarrow$ Glucose + Pi **(Reaction 1)**
ATP + Glucose $\rightarrow$ ADP + Glucose 6-phosphate **(Reaction 2)**
the standard free energy change of ATP hydrolysis at 25 °C is _____ kJ/mol.
The equilibrium constants for **Reaction 1** and **Reaction 2** are 360 and 800, respectively; Gas constant $R = 8.314\ J\ mol^{-1}\ K^{-1}$.
(*Round off to two decimal places*)

Answer— (32.00 to -30.00) Explanation

Adding the two reactions gives: ATP + $H_2O \rightarrow$ ADP + Pi
K(overall) = K1 * K2 = 360 * 800 = 288000
$\Delta G° = -RT\ln K$
$\Delta G° = -(8.314\ J/mol\cdot K) * (298\ K) * \ln(288000)$
$\Delta G° = -(8.314) * (298) * (12.57)\ J/mol = -31058\ J/mol$
$\Delta G° = -31.06\ kJ/mol$
The standard free energy change of ATP hydrolysis is -31.06 kJ/mol.