Q.No. 1 Rajiv Gandhi Khel Ratna Award was conferred_____Mary Kom, a six-time world champion in boxing, recently in a ceremony_____the Rashtrapati Bhawan (the President's official residence) in New Delhi.

(A) with, at
(B) on, in
(C) on, at
(D) to, at

1 C.

Details: "**to confer something (up)on someone"** means to grant something. (upon is more formal than on). **"at"** is used when reffering to building as locations in a city; "**in**" is used when something inside a space.

Q.No. 2 Despite a string of poor performances, the chances of K. L. Rahul's selection in the team are_____.

(A) slim
(B) bright
(C) obvious
(D) uncertain

2 B.

Details: "Despite" means without being affected by. So however K.L. Rahul performs but he has a great chance to make into the team.

Q.No. 3 Select the word that fits the analogy:

Cover : Uncover :: Associate : _____

(A) Unassociate
(B) Inassociate
(C) Misassociate
(D) Dissociate

3 D.

Details: **Dissociate** is the antonym (opposite by meaning) of associate, like uncover is antonym of cover.

Q.No. 4 Hit by floods, the kharif (summer sown) crops in various parts of the country have been affected. Officials believe that the loss in production of the kharif crops can be recovered in the output of the rabi (winter sown) crops so that the country can achieve its food-grain production target of 291 million tons in the crop year 2019-20 (July-June). They are hopeful that good rains in July-August will help the soil retain moisture for a longer period, helping winter sown crops such as wheat and pulses during the November-February period.

Which of the following statements can be inferred from the given passage?

(A) Officials declared that the food-grain production target will be met due to good rains.
(B) Officials want the food-grain production target to be met by the November-February period.
(C) Officials feel that the food-grain production target cannot be met due to floods.
(D) Officials hope that the food-grain production target will be met due to a good rabi produce.

4 D.

Details: this is the correct option because it is more accurate while other options have little error or not exact.

Q.No. 5 The difference between the sum of the first $2n$ natural numbers and the sum of the first n odd natural numbers is _____.

(A) $n^2 - n$
(B) $n^2 + n$
(C) $2n^2 - n$
(D) $2n^2 + n$

5 B.

Details: As we know, $1 + 2 + \ldots + n = n(n+1)/2$, for "$n$" a natural number.
So for "2n" natural number, sum (S)= 2n(2n+1)/2
And we also know, sum of first "n" odd natural numbers = n^2
So, $2n(2n+1)/2 - n^2 = n^2 + n$

Q.No. 6 Repo rate is the rate at which Reserve Bank of India (RBI) lends commercial banks, and reverse repo rate is the rate at which RBI borrows money from commercial banks.

Which of the following statements can be inferred from the above passage?

(A) Decrease in repo rate will increase cost of borrowing and decrease lending by commercial banks.
(B) Increase in repo rate will decrease cost of borrowing and increase lending by commercial banks.
(C) Increase in repo rate will decrease cost of borrowing and decrease lending by commercial banks.
(D) Decrease in repo rate will decrease cost of borrowing and increase lending by commercial banks.

6 D.

Details: Decrease in Repo rate leads to less cost of borrowing by commercial banks which will decrease the rate of interest taken by banks from customers.

Hence, loan demand will increase by customers as their borrowing cost also decreased hence banks will increase lending.

Q.No. 7 P, Q, R, S, T, U, V, and W are seated around a circular table.

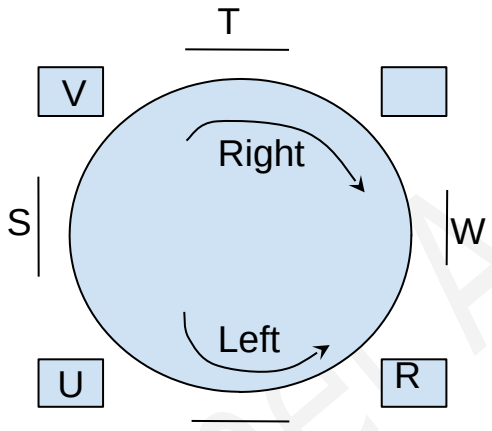
I. S is seated opposite to W.
II. U is seated at the second place to the right of R.
III. T is seated at the third place to the left of R.
IV. V is a neighbour of S.

Which of the following must be true?

(A) P is a neighbour of R.
(B) Q is a neighbour of R.
(C) P is not seated opposite to Q.
(D) R is the left neighbour of S.

7 C.

Details: Possible arrangement:



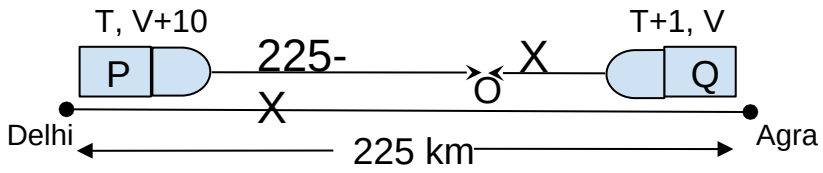
Although other arrangements are also possible but option C is surely right in every case.

Q.No. 8 The distance between Delhi and Agra is 233 km. A car *P* started travelling from Delhi to Agra and another car *Q* started from Agra to Delhi along the same road 1 hour after the car *P* started. The two cars crossed each other 75 minutes after the car *Q* started. Both cars were travelling at constant speed. The speed of car *P* was 10 km/hr more than the speed of car *Q*. How many kilometers the car *Q* had travelled when the cars crossed each other?

(A) 66.6
(B) 75.2
(C) 88.2
(D) 116.5

8 B.

Details:



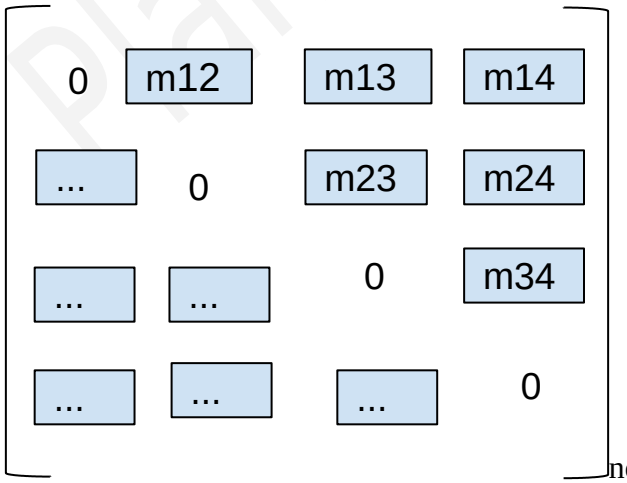
As per question, P started from Delhi at time "T=0", with speed V+10 km/hr and Q started 1 hour later at "T+1=1 hour" time with speed V km/hr.
After 75 minutes of Q started, both P and Q met at point O.
Suppose X is the distance travelled by Q in 75 minutes and rest distance i.e., 225-X is travelled in 60+75 (1+1.25 hours) minutes.
As, 60 minutes = 1 hour, 15 minutes = 0.25 hours.
So, X= V*1.25 and, 225-X=(V+10)*2.25
=> 225-V*1.25=(V+10)*2.25
=>225-1.25V=2.25V+22.5
=>225-22.5=2.25V+1.25V
=>V=202.5/3.5 km/hr
=>V ≈ 59 km then X=V*1.25 km => X≈75 km

Q.No. 9 For a matrix $M = [m_{ij}]$; $i,j = 1,2,3,4$, the diagonal elements are all zero and $m_{ij} = -m_{ji}$. The minimum number of elements required to fully specify the matrix is_____.

(A) 0
(B) 6
(C) 12
(D) 16

9 B

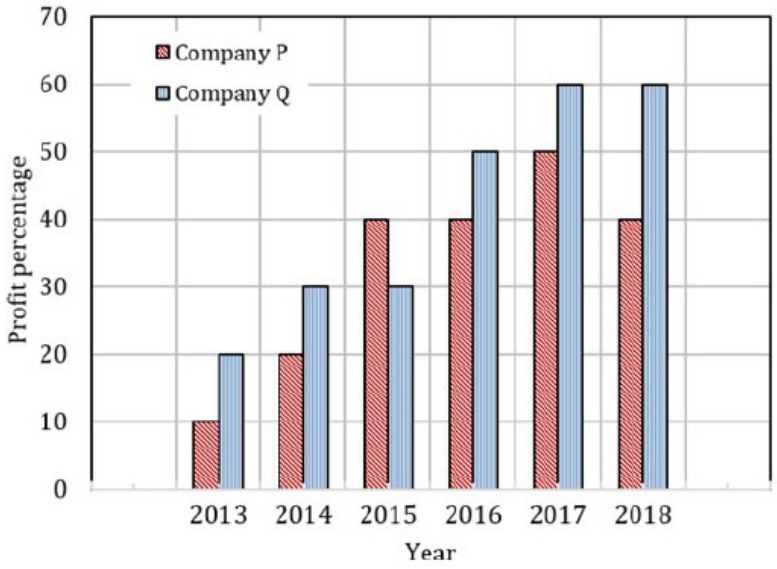
Details: As given it is 4*4 matrix with diagonal elements=0. So, possible matrix, M=



now, as $m_{ij}=-m_{ji}$ so, it is a skew-symmetric

matrix and hence it needs only ½ of the non-diagonal elements (½*12) = 6 (Both sides of the diagonal matrix are equal by magnitude in the skew-symmetric matrix).

Q. No. 10. The profit shares of two companies P and Q are shown in the figure. If the two companies have invested a fixed and equal amount every year, then the ratio of the total revenue of company P to the total revenue of company Q, during 2013 - 2018 is_____.



(A) 15 : 17
(B) 16 : 17
(C) 17 : 15
(D) 17 : 16

10 B

Details: As given in question,

P	%ge profit	10	20	40	40	50	40
Q		20	30	30	50	60	60

Suppose Rs X (amount) invested every year by Company P, and Company Q.
Then the total revenue by P from 2013-2018, R_p is:
$R_p = X/100 * (110 + 120 + 140 + 140 + 150 + 140)$
$\Rightarrow R_p = 8X$

And the total revenue by Q company from 2013-2018, R_Q is:
$R_Q = X/100 * (120 + 130 + 130 + 150 + 160 + 160)$
$\Rightarrow R_Q = X/100 * 850$
$\Rightarrow R_Q = 17X/2$
$\therefore$ Required ratio, $R_p/R_Q = 8X/(17X/2)$
$\Rightarrow R_p/R_Q = 16/17$

BT

Q.No. 1 Protein P becomes functional upon phosphorylation of a serine residue. Replacing this serine with _____ will result in a phosphomimic mutant of P.

(A) alanine
(B) aspartic acid
(C) phenylalanine
(D) lysine

1 B.

Details: Serine is often mutated to glutamic acid or aspartic acid to mimic phosphorylation of serine residue. Phosphomimetics are amino acid substitutions that mimic a phosphorylated protein, thereby activating (or deactivating) the protein. Within cells, proteins are modified at serine, tyrosine, and threonine amino acids by adding a phosphate group. Phosphorylation is a common mode of activating or deactivating a protein as a form of regulation. However, some non-phosphorylated amino acids appear chemically similar to phosphorylated amino acids. Therefore, by replacing an amino acid, the protein may maintain a higher level of activity. For example, **aspartic acid is chemically similar to phospho-serine (due to its bulkiness and negative charge).** Therefore, when an aspartic acid replaces a serine, it is a phosphomimetic of phospho-serine and can make the protein always in its phosphorylated form.

Q.No. 2 Ras protein is a

(A) trimeric GTPase involved in relaying signal from cell surface to nucleus.
(B) monomeric GTPase involved in relaying signal from cell surface to nucleus.
(C) trimeric GTPase involved in regulation of cytoskeleton.
(D) monomeric GTPase involved in regulation of cytoskeleton.

2 B.

Details: The Ras protein (regulators of signal transduction) is a monomeric globular protein associated with the plasma membrane that binds either GDP ("off" state) or GTP ("on" state). Involved in many cellular functions like cell proliferation, differentiation, migration, apoptosis. This protein is involved in the MAPK pathway.

Q.No. 3 Which of the following statements are **CORRECT**?

[P] Viruses can play a role in causing human cancer

[Q] A tumor suppressor gene can be turned off without any change in its DNA sequence

[R] Alteration in miRNA expression levels contributes to the development of cancer

(A) P and Q only
(B) Q and R only
(C) P and R only
(D) P, Q and R

3 D.

Details: Both DNA and RNA viruses have been shown to be capable of causing cancer in humans. **DNA viruses**: Epstein-Barr virus, human papillomavirus, hepatitis B virus, and human herpesvirus-8.
RNA viruses: Human T lymphotropic virus type 1 and hepatitis C viruses.
MicroRNAs (miRNAs) are endogenous, small non-coding RNAs that function in regulation of gene expression at the post-translational level. These may function as either oncogenes or tumor suppressors under certain conditions. miRNA expression is dysregulated in human cancer through various mechanisms. Ex- miR-21, High expression levels of miR-21 may be a characteristic of cancer cells and represent a common feature of pathological cell growth or cell stress.
There are many regulators like insulators, enhancers, promoters, and epigenetics that can control gene expression.

Q.No. 4 Which class of antibody is first made by developing B cells inside bone marrow?

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

4 D.

Details: IgM is the first antibody to appear on the surface of a developing B cell. It is the major class of antibodies secreted into the blood in the early stages of a primary antibody response, on first exposure to an antigen.

Q.No. 5 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r] regarding mammalian cells.

Assertion [a]: Cells use Ca^{2+}, and not Na^{+}, for cell-to-cell signaling

Reason [r]: In the cytosol, concentration of Na^{+} is lower than that of Ca^{2+}

(A) Both [a] and [r] are true and [r] is the correct reason for [a].
(B) Both [a] and [r] are true but [r] is not the correct reason for [a].
(C) Both [a] and [r] are false.
(D) [a] is true but [r] is false.

5 D.

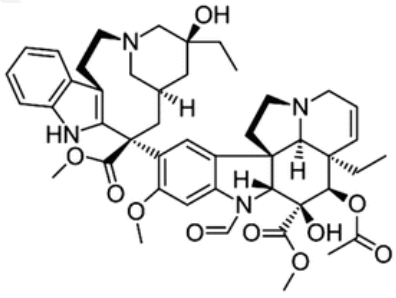
Details: the concentration of calcium in the extracellular fluid is 10,000 times greater than in the cytosol. Intracellular conc. of Na^{+} and Ca^{2+} are 15 and 10^{-4} mM while extracellular con. of Na+ and Ca2+ are 142 and 1 mM respectively in cardiac cells. So the reason is wrong but the assertion is right Ca^{2+} is used as a cell-to-cell signaling messenger, rather than Na^{+}.

Q.No. 6 Vincristine and vinblastine, two commercially important secondary metabolites from *Catharanthus roseus*, are examples of

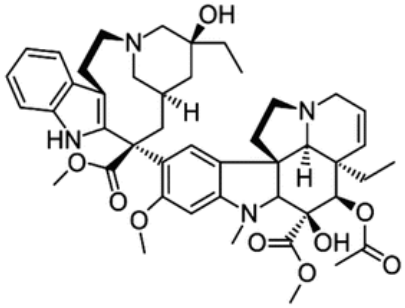
(A) alkaloids.
(B) flavonoids.
(C) terpenoids.
(D) steroids.

6 A.

Details: Drugs vincristine and vinblastine are found in the leaves of periwinkle plants. These chemicals are collectively referred to as **vinca alkaloids**, after the plant's original Latin name Vinca rosea. Vinblastine is used to treat Hodgkin's disease, while vincristine is used clinically in the treatment of children's leukaemia. Both are neurotoxic.



A.Vincristine



B.Vinblastine

Q.No. 7 DNA synthesized from an RNA template is called

(A) recombinant DNA.
(B) transcript.
(C) T-DNA.
(D) complementary DNA.

7 D.

Details: Complementary DNA (**cDNA**) is a DNA synthesized from a single-stranded RNA (e.g., mRNA or miRNA) template in a reaction catalyzed by enzyme reverse transcriptase. It is often used to clone eukaryotic genes in prokaryotes. It is used in biotechnology to express protein by the cell which does not express in natural condition. cDNA is also produced naturally by retroviruses (such as HIV-1, HIV-2, simian immunodeficiency virus, etc.) and then integrated into the host's genome, where it creates a provirus. **cDNA library** is also important to store coding sequence.

Q.No. 8 Two monomeric His-tagged proteins of identical molecular weight are present in a solution. pIs of these two proteins are 5.6 and 6.8. Which one of the following techniques can be used to separate them?

(A) Denaturing polyacrylamide gel electrophoresis
(B) Size-exclusion chromatography
(C) Ion-exchange chromatography
(D) Nickel affinity chromatography

8 C.

Details: Ion-exchange chromatography (I-E Ch) can recognise the pI difference due to its charge sensitivity. I-E Ch is a widely employed method utilizing immobilized metal-affinity chromatography (IMAC) to purify recombinant proteins containing a short affinity tag consisting of polyhistidine residues. IMAC is based on the interactions between a transition metal ion (Co^{2+}, Ni^{2+}, Cu^{2+}, Zn^{2+}) immobilized on a matrix and **specific amino acid side chains**. Histidine is the amino acid that exhibits the strongest interaction with immobilized metal ion matrices, as electron donor groups on the histidine's imidazole ring readily form coordination bonds with the immobilized transition metal. Peptides containing sequences of consecutive histidine residues are efficiently retained on IMAC column matrices. Following washing of the matrix material, peptides containing polyhistidine sequences can be easily eluted by either adjusting the pH of the column buffer or adding free imidazole to the column buffer.

Q.No. 9 During a positive-negative selection process, transformed animal cells expressing _____ are killed in presence of ganciclovir in the medium.

(A) pyruvate kinase
(B) viral thymidine kinase
(C) viral serine/threonine kinase
(D) viral tyrosine kinase

9 B.

Details: **Ganciclovir** is a synthetic nucleoside analogue of 2'-deoxyguanosine that inhibits replication of herpes viruses both in vitro and in vivo. Ganciclovir's antiviral activity inhibits virus replication. This inhibitory action is highly selective as the drug must be converted to the active form by a virus-encoded cellular enzyme, thymidine kinase (TK). TK catalyzes the phosphorylation of ganciclovir to the monophosphate, which is then subsequently converted into the diphosphate by cellular guanylate kinase and into the triphosphate by a number of cellular enzymes. In vitro, ganciclovir triphosphate stops replication of herpes viral DNA. When used as a substrate for viral DNA polymerase, ganciclovir triphosphate competitively inhibits dATP leading to the formation of 'faulty' DNA. This is where ganciclovir triphosphate is incorporated into the DNA strand replacing many of the adenosine bases. This results in the prevention of DNA synthesis, as phosphodiester bridges can longer to be built, destabilizing the strand. Ganciclovir inhibits viral DNA polymerases more effectively than it does cellular polymerase, and chain elongation resumes when ganciclovir is removed.

Q.No. 10 A vector derived from which one of the following viruses is used for high-frequency genomic integration of a transgene in animal cells?

(A) Adenovirus
(B) Adeno-associated virus
(C) Lentivirus
(D) Herpes simplex virus

10 C.

Details: Efficient gene transfer and stable transgene expression are two key features required for effective human gene therapy. The lentiviral infection has advantages over other gene therapy methods including high-efficiency infection of dividing and non-dividing cells, long-term stable expression of a transgene, and low immunogenicity.

Comparison	Lentivirus	Adenovirus	AAV
Genome	ssRNA	dsDNA	ssDNA

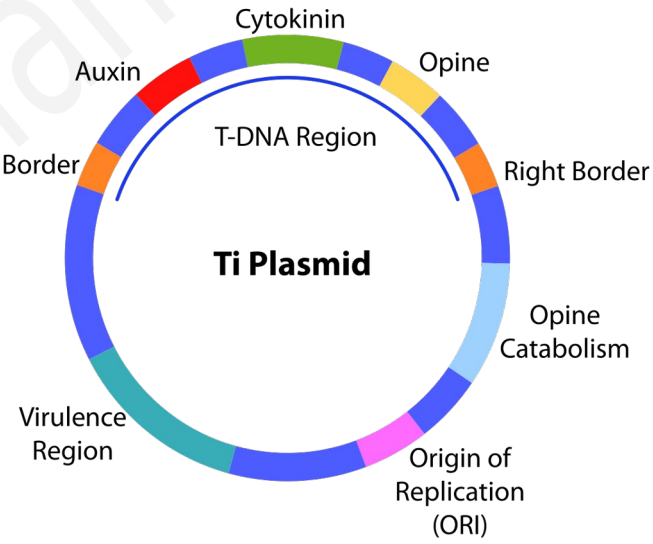
Integration	Yes	No	No
Packaging Capacity	4 kb	5.5 kb	2 kb
Time to peak expression	**72 hrs**	**36-72 hrs**	cell: 7 days; animals: 2 weeks
Sustainable time	**stable expression**	**transient expression**	> 6 months
Cell Type	most dividing/non-dividing Cells		
Titer	10^8 TU/ml	10^11 PFU/ml	10^12 vg/ml
Animal experiment	low efficiency	lowest efficiency	most suitable
Immune Response	medium	medium	mild

Q.No. 11 Which one of the following statements about *Agrobacterium* Ti plasmid is **CORRECT**?

(A) *Vir* genes are located within the T-DNA segment
(B) Phytohormone biosynthesis genes are located outside the T-DNA segment
(C) Opine catabolism genes are located within the T-DNA segment
(D) Opine biosynthesis genes are located within the T-DNA segment

11 D.

Details:



Q.No. 12 Which of the following types of molecules act as biological catalysts?

[P] Protein

[Q] RNA

[R] Phospholipid

(A) P and Q only
(B) P and R only
(C) Q and R only
(D) P, Q and R

12 A.

Details: RNA is recognized as an active catalyst in biology, in self-splicing of group I and group II introns, in various small ribozymes, and also as the catalytic center of the ribosome and spliceosome. Although RNAs are capable of catalyzing some reactions, most biological reactions are catalyzed by proteins. Phospholipids play multiple and essential roles in cells, as components of biological membranes. Although phospholipid bilayers provide the supporting matrix and surface for many enzymatic reactions, their inherent reactivity and possible catalytic role have not been highlighted.

Q.No. 13 Which one of the following media components is used to maintain pH in mammalian cell culture?

(A) $CaCl_2$
(B) $MgSO_4$
(C) NaCl
(D) $NaHCO_3$

13 D.

Details: Sodium bicarbonate is a buffer used to stabilize pH. Cells in culture produce CO_2 but require only small amounts of the compound for growth and survival. CO_2 affects the pH of the medium. Increasing atmospheric CO_2 decreases the pH of the medium. $NaHCO_3$ buffer contain both $NaHCO_3$ and H_2CO_3.

$HCl + NaHCO_3 <----> H_2CO_3 + NaCl$

$NaOH + H_2CO_3 <----> NaHCO_3 + H_2O$

Q.No. 14 Which of the following are energy transducing membranes?

[P] Plasma membrane of bacteria

[Q] Inner membrane of chloroplasts

[R] Inner membrane of mitochondria

(A) P and Q only
(B) P and R only
(C) Q and R only
(D) P, Q and R

14 B.

Details: The **energy transducing membranes** are the **plasma membrane of** prokaryotic **bacteria** and blue-green algae, the inner **membrane** of mitochondria, and the **thylakoid membrane** (3rd membrane) of chloroplasts. Mesosomes are thought to play a role in energy transduction in bacteria. However, energy transduction in bacteria is much more complicated.

Q.No. 15 Amino acid sequences of cytochrome c and ribulose 5-phosphate epimerase from 40 organisms were chosen and phylogenetic trees were obtained for each of these two protein families.

Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].

Assertion [a]: The two trees will not be identical

Reason [r]: The nature and frequency of mutations in the two families are different

(A) Both [a] and [r] are true and [r] is the correct reason for [a].
(B) Both [a] and [r] are true but [r] is not the correct reason for [a].
(C) Both [a] and [r] are false.
(D) [a] is false but [r] is true.

15 A.

Details: Mutations are random hance mutation in different population/organism are mostly different. Mutation can differ by its frequency and its type.

Q.No. 16 A microorganism isolated from a salt-rich (salt concentration ~2 M) lake was found to possess diglycerol tetraethers, with polyisoprenoid alcohol side chains, as the major lipid component of its cell membrane. The isolated organism is

(A) a planctomycete.
(B) a cyanobacteria.
(C) a unicellular amoeba.
(D) an archaea.

16 D.

Details:
1st hint: extracted from the salt-rich lake, halophile.
2nd hint: The lipids of the Archaea are now known to contain many unique and characteristic polar lipids based on **2,3-dialkyl-*sn*-glycerol** backbones. The alkyl groups are isoprenoid in nature, and the simplest molecules of this type are derivatives of 2,3-diphytanyl-*O*-*sn*-glycerol (archaeol), i.e. with two C20 isoprenoid units (or occasionally sesterterpenyl - C25) attached to positions *sn*-2 and *sn*-3 of glycerol by ether linkages (sometimes designated C40 ether lipids).

Q.No. 17 A function f is as follows:

$$f(x) = \begin{cases} 15 & if\ x < 1 \\ cx & if\ \ x \geq 1 \end{cases}$$

The function f is a continuous function when c is equal to ___15_____ (answer is an integer).

17 1,3,5 or 15

Details: Continuous function means the function will start from 15 and go further.
For x=1, f(x=1)=cx=15
=>c*1=15, so, c=15
For x>1, f(x>1)=cx=15
=>c 15 (It can be fraction or integer also like 1, 3 or 5)

Q.No. 18 Given that $Z = X^2 + Y^2$, the value of $\frac{\partial Z}{\partial X}$ for X = 1 and Y = 0 is _____ (answer is an integer).

18 2

Details: $Z = X^2 + Y^2$

$$\frac{\delta Z}{\delta X} = \delta X^2/\delta X + \delta(Y^2)/\delta X$$

$=>\delta Z/\delta X = 2X + 0$ (for Y=0)

$=> \delta Z/\delta X = 2$ (for X = 1)

Q.No. 19 The elemental composition of dry biomass of a yeast species is $CH_{1.6}O_{0.4}N_{0.2}S_{0.0024}P_{0.017}$. The contribution of carbon to the dry biomass is _____% (round off to 2 decimal places).

19 51.27

Details: Given: atomic weights of H, C, N, O, P and S are 1, 12, 14, 16, 31 and 32, respectively.

Contribution of Carbon = Atomic weight of carbon * 100
Atomic weight of Biomass

$$\Rightarrow \text{Contribution of Carbon} = \frac{12*100}{1*12 + (1.6*1) + (16*0.4) + (14*0.2) + (0.0024*32) + (0.017*31)}$$

$=1200/23.4038 = 51.27$

Q. No. 20. Solvents A and B are completely immiscible. Solute S is soluble in both these solvents. 100 g of S was added to a container which has 2 kg each of A and B. The solute is 1.5 times more soluble in solvent A than in solvent B. The mixture was agitated thoroughly and allowed to reach equilibrium. Assuming that the solute has completely dissolved, the amount of solute in solvent A phase is _____ g.

20 60

Details: Let us consider the amount of solute in solvent B phase = x gram
Given that the solute is 1.5 times more soluble in solvent A.
Hence, amount of solute in solvent A phase = 1.5x.
x + 1.5x =100
=> 2.5x = 100, => x=40 grams dissolved in solvent B and hence, 60 gram (100-40) is dissolved in solvent A.

Q.No. 21 The number of molecules of a nucleotide of molecular weight 300 g/mol present in 10 picomoles is _____ x 10^{12} (round off to 2 decimal places).

21 **$6.02 * 10^{12}$**

Details: Given, Molecular weight = 300g and as we know, 1 mole = $6.02 * 10^{23}$ molecules and 1 picomole = 10^{-12}
So, #molecules in 10 picomole = $6.02 * 10^{23} * 10 * 10^{-12}$
$= 6.02 * 10^{12}$

Q.No. 22 To facilitate mass transfer from a gas to a liquid phase, a gas bubble of radius *r* is introduced into the liquid. The gas bubble then breaks into 8 bubbles of equal radius. Upon this change, the ratio of the interfacial surface area to the gas phase volume for the system changes from *3/r* to *3n/r*. The value of *n* is _____.

22 8

Details: As we know, Surface area (S) of sphere (gas bubble) = $4\Pi r^2$,
Volume (V) of sphere = $4\Pi r^3/3$
Suppose, big bubble has "r" radius. So $S_1 = 4\Pi r^2$, $V_1 = 4\Pi r^3/3$
After breaking its radius became "r/8". So, $S_2 = 4\Pi(r/8)^2$, $V_2 = 4\Pi(r/8)^3/3$

Now, $\frac{S1}{V1} = 4\Pi r^2/4\Pi r^3/3 = 3/r$

$\frac{S2}{V2} = 4\Pi r^2 * 8^3 * 3/4\Pi r^3 * 8^2 = 3*8/r$

Now, as per question, $S_1/V_1 = 3/r$ and $S_2/V_2 = 3n/r$
So, by comparing 3n/r with 3*8/r, the value of n = 8.

Q.No. 23 The largest eigenvalue of the matrix $\begin{bmatrix} 4 & 1 \\ -2 & 1 \end{bmatrix}$ is _____.

23 3

Details: **A.V** =ƛ**V**
In this equation A is an n-by-n matrix, v is a non-zero n-by-1 vector and λ is a scalar. The value of λ is the eigenvalue of the matrix **A**.
The characteristic equation is: |**A**-ƛ.**I**| = 0,

given, $\mathbf{A} = \begin{bmatrix} 4 & 1 \\ -2 & 1 \end{bmatrix}$

$|\mathbf{A}-ƛ.\mathbf{I}| = \left| \begin{bmatrix} 4 & 1 \\ -2 & 1 \end{bmatrix} - \begin{bmatrix} ƛ & 0 \\ 0 & ƛ \end{bmatrix} \right| = 0$

$\Rightarrow \begin{bmatrix} 4-ƛ & 1 \\ -2 & 1-ƛ \end{bmatrix} = 0$

$\Rightarrow ƛ2 - 5ƛ + 6 = 0$

$\Rightarrow ƛ = 2,3$

So, maximum value of **λ** is 3.

Q.No. 24 A normal random variable has mean equal to 0, and standard deviation equal to 3. The probability that on a random draw the value of this random variable is greater than 0 is _____ (round off to 2 decimal places).

24 0.5

Details: Find Z score. **Z= (x-μ)/σ**, **μ** is the mean value; **σ** is standard deviation. Z = 0-0/3 =0 now look at the Z-table, P(Z<0)=0.5. **P(Z>0)= 1-P(Z<0) =0.5**

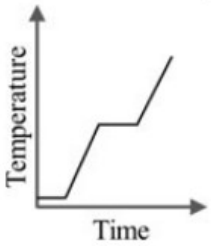
Q.No. 25 A variable Y is a function of t. Given that $Y(t = 0) = 1$ and $Y(t = 1) = 2$, $\frac{dY}{dt}$ in the interval t = [0, 1] can be approximated as _____.

25 1

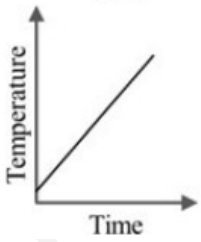
Details: dY/dt = (2-1)/(1-0) = 1

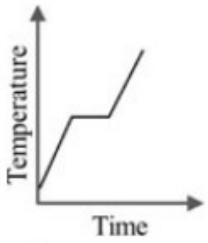
Q.No. 26 A block of ice at 0 °C is supplied heat at a constant rate to convert ice to superheated steam. Which one of the following trajectories correctly represents the trend of the temperature of the system with time? Assume that the specific heat of H_2O is not a function of temperature.

(A)

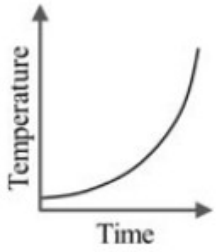


(B)



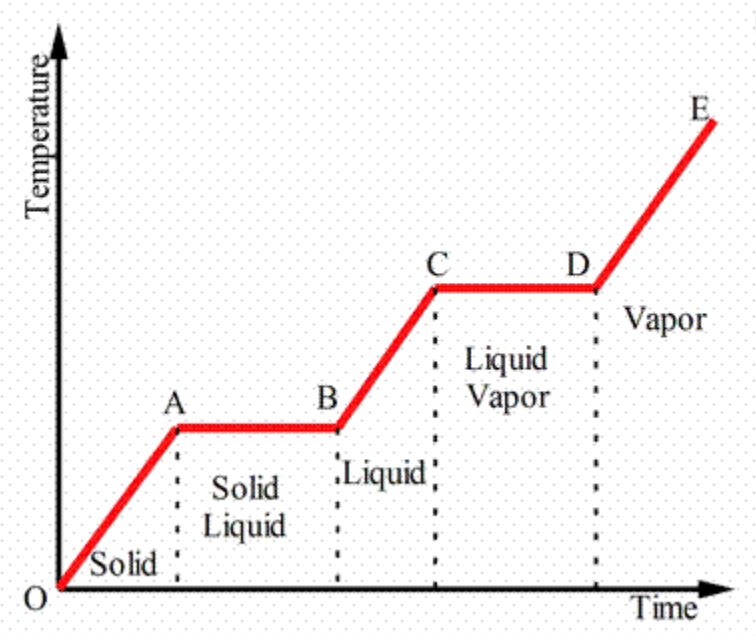


(D)



26 A.

Details:



Q.No. 27 The DNA sequence shown below is to be amplified by PCR:

5′GCTAAGATCTGAATTTTCC.....TTGGGCAATAATGTAGCGC3′
3′CGATTCTAGACTTAAAAGG.....AACCCGTTATTACATCGCG5′

Which one of the following pair of primers can be used for this amplification?

(A) 5′GGAAATTCAGATCTTAGT3′ and 5′TGGGCAATAATGTAGCGC3′
(B) 5′GCTAAGATCTGAATTTTC3′ and 5′GCGCTACATTATTGCCCA3′
(C) 5′CGGAAATTCAGATCTTAG3′ and 5′GCGCTACATTATTGCCCA3′
(D) 5′GCTAAGATCTGAATTTTC3′ and 5′TGGGCAATAATGTAGCGC3′

27 B.

Details: Forward prime reads from 5' to 3'. It binds to the 3' end of the bottom strand. so is identical to the top strand. That means the hypothetical forward primer would be GCTAA. Backward primer reads from 5' to 3'. The 4 bases that bind to the 3' of the top strand are TCGCG But as the primer starts at the 3' end so it should be read as GCGCT.

Q.No. 28 Which of the following statements about immune response are **CORRECT**?

[P] T cells are activated by antigen-presenting cells

[Q] Foreign peptides are not presented to helper T cells by Class II MHC proteins

[R] Dendritic cells are referred to as professional antigen-presenting cells

(A) P and R only
(B) P and Q only
(C) Q and R only
(D) P, Q and R

28 A

Details: An antigen-presenting cell (APC) is a cell that displays antigen complexed with major histocompatibility complexes (MHCs) on their surfaces. T cells may recognize these complexes using their T cell receptors (TCRs). APCs process antigens and present them to T-cells. When a macrophage engulfs a microorganism, it partially digests it and displays peptide fragments of the microbe on its surface, bound to MHC molecules. The T lymphocyte recognizes the foreign fragment attached to the MHC molecule and binds to it, stimulating an immune response. Class I MHC molecules span the membrane of almost every

cell in an organism, while class II molecules are restricted to cells of the immune system. MHC class II presents foreign antigens to helper T (T_h) cells. Dendritic cells, macrophages, and B cells present Foreign antigens and are known as "professional" antigen presenting cells due to their ability to present exogenous antigens using MHC II receptors.

Q.No. 29 Which of the following statements are **CORRECT** about eukaryotic cell cycle?

[P] CDKs can phosphorylate proteins in the absence of cyclins

[Q] CDKs can be inactivated by phosphorylation

[R] Degradation of cyclins is required for cell cycle progression

[S] CDKs are not involved in chromosome condensation

(A) P and R only
(B) P and S only
(C) P, Q and R only
(D) Q and R only

29 D.

Details: Cyclin-CDK complexes phosphorylate their substrates by transferring phosphate groups from ATP to specific stretches of amino acids in the substrates. CDKs are phosphorylated at some and other sites are dephosphorylated in order to be activated. Cyclin degradation is equally important for progression through the cell cycle. **Cell cycle arrest can occur if cyclins fail to degrade.** In many organisms, **M-Cdk (M-CyclinCDK complex)** also triggers **chromosome condensation**, nuclear envelope breakdown, actin cytoskeleton rearrangement, and the reorganization of the Golgi apparatus and endoplasmic reticulum.

Q. No. 30. W, X and Y are the intermediates in a biochemical pathway as shown below:

$$S \cdots\cdots\rightarrow W \rightarrow X \rightarrow Y \rightarrow Z$$

Mutants auxotrophic for Z are found in four different complementation groups, namely Z1, Z2, Z3 and Z4. The growth of these mutants on media supplemented with W, X, Y or Z is shown below (Yes: growth observed; No: growth not observed):

What is the order of the four complementation groups in terms of the step they block?

(A) S ····Z1→ W →Z2 X →Z3 Y →Z4 Z

(B) S ····Z4→ W →Z2 X →Z1 Y →Z3 Z

(C) S ····Z3→ W →Z1 X →Z2 Y →Z4 Z

(D) S ····Z4→ W →Z1 X →Z2 Y →Z3 Z

30 B.

Details: Z4 can grow on W ("Yes" can be seen in Z4, W box). So option B and D can be the right answer.

Similarly, see Z2 and Z4 can grow on X. And in the B and D option, B option shows Z2 can grow on X. So option B is the correct answer.

Q.No. 31 In tomato plant, red (*R*) is dominant over yellow (*r*) for fruit color and purple (*P*) is dominant over green (*p*) for stem color. Fruit color and stem color assort independently. The number of progeny plants of different fruit/stem colors obtained from a mating are as follows:

Red fruit, purple stem – 145

Red fruit, green stem – 184

Yellow fruit, purple stem – 66

Yellow fruit, green stem – 47

What are the genotypes of the parent plants in this mating?

(A) *RrPp* x *Rrpp*

(B) *RrPp* x *RrPp* 9:3:3:1

(C) *RRPP* x *rrpp* All one shape

(D) *RrPP* x *Rrpp*

31 A.

Details: Option D gives no green stem (pp). So it's not possible. Option C gives a single morphological plant. Option B is a typical F2 dihybrid cross gives 9:3:3:1 phenotypic ratio.

Punnett square for option A:

	RP	Rp	rP	rp
Rp	RRPp	RRpp	RrPp	Rrpp
Rp	RRPp	RRpp	RrPp	Rrpp
rp	RrPp	rrpp	rrPp	rrpp
rp	RrPp	rrpp	rrPp	rrpp

So, Red tomato with Purple stem = 6/16 = 0.37

Red tomato with Green stem = 6/16, Yellow tomato with Purple stem= 2/16 =0.13

Yellow tomato with Green stem = 2/16

These ratios are nearly equal to the data given in the question.

Q.No. 32 Some of the cytokinins used in plant tissue culture media are given below:

[P] BAP

[Q] Zeatin

[R] Kinetin

[S] 2iP

Which of these are synthetic analogs?

(A) P and Q only
(B) Q and S only
(C) R and S only
(D) P and R only

32 D.

Details: Among cytokinins, zeatin and 2-isopentyladenine (**2iP**) are **naturally** occurring cytokinins, whereas, N^6 benzyladenine (BA), 6-furfuryl-aminopurine (kinetin, Kin), and [1-Phenyl-3-(1,2,3,-thiadiazol-5-yl)] urea (thidiazuron, TDZ) are **synthetic** cytokinins. **6-Benzylaminopurine, benzyl adenine, BAP or BA** is a first generation cytokinin plant growth regulator influencing plant growth and development, setting blossoms and stimulating fruit richness by stimulating cell division. It is an inhibitor of respiratory kinase in plants, and increases postharvest life of green vegetables. **Zeatin** was discovered in immature corn kernels from the genus Zea. It promotes growth of lateral buds and when sprayed on meristems stimulates cell division to produce bushier plants. **Kinetin** is a cytokinin-like

synthetic compound that regulates cell growth in plants. **Kinetin** was the first cytokinin discovered. It is also adenine-based. It was given the name **kinetin** because of its ability to induce cell division, provided that auxin was present in the medium.

Q.No. 33 Carl Woese used the gene sequence of which one of the following for phylogenetic taxonomy of prokaryotes?

(A) A ribosomal RNA of large ribosomal subunit
(B) A ribosomal RNA of small ribosomal subunit
(C) A ribosomal protein of large ribosomal subunit
(D) A ribosomal protein of small ribosomal subunit

33 B.

Details: 16S ribosomal RNA (or 16S rRNA) is the component of the 30S small subunit of a prokaryotic ribosome that binds to the Shine-Dalgarno sequence. The genes coding for it are referred to as 16S rRNA gene and are used in reconstructing phylogenies, due to the slow rates of evolution of this region of the gene. Carl Woese and George E. Fox were two of the people who pioneered the use of 16S rRNA in phylogenetics in 1977.

Q.No. 34 A list of pathogens (Group I) and a list of anti-microbial agents (Group II) used to treat their infections are given below. Match the pathogens with the corresponding anti-microbial agents.

Group I	Group II
[P] Influenza A virus	1. Isoniazid
[Q] Fungus	2. Amantadine
[R] Plasmodium	3. Fluconazole
[S] Mycobacterium	4. Artemisinin
	5. Iodoquinol

(A) P-4, Q-3, R-2, S-5
(B) P-5, Q-2, R-4, S-1
(C) P-2, Q-3, R-4, S-1
(D) P-2, Q-3, R-1, S-5

34 C.

Details: **Amantadine** is effective against all influenza A subtypes that have previously caused disease in humans e.g. H1N1, H2N2 and H3N2 (but not against influenza B virus because the protein M2 is unique to influenza A viruses). The use of amantadine is associated with the rapid emergence of drug-resistant variants. **Fluconazole** is used to prevent and treat a variety of fungal and yeast infections. It belongs to a class of drugs called azole antifungals. It works by stopping the growth of certain types of fungus. **Artemisinin** and its semisynthetic derivatives are a group of drugs used against malaria due to Plasmodium falciparum. Treatments containing an artemisinin derivative (artemisinin-combination therapies, ACTs) are standard treatment worldwide for P. falciparum malaria. **Isoniazid** is a prodrug that inhibits the formation of the mycobacterial cell wall. **Isoniazid** must be activated by KatG, a bacterial catalase-peroxidase enzyme in Mycobacterium tuberculosis. The exact **mechanism of action** of **iodoquinol** is unknown. **Iodoquinol** acts against the trophozoites of Entamoeba histolytica . **Iodoquinol** produces its amebicidal effect at the site of infection, since it is poorly absorbed from the gastrointestinal tract and can reach high concentrations in the intestinal lumen.

Q.No. 35 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].

Assertion [a]: Dam methylase protects *E. coli* DNA from phage endonucleases

Reason [r]: *E. coli* Dam methylase methylates the adenosine residue in the sequence "GATC"

(A) Both [a] and [r] are true and [r] is the correct reason for [a]
(B) Both [a] and [r] are true but [r] is not the correct reason for [a]
(C) Both [a] and [r] are false
(D) [a] is false but [r] is true

35 D.

Details: Dam methylation is important for strand discrimination during repair of replication errors, controlling the frequency of initiation of chromosome replication at *oriC*, and regulation of transcription initiation at promoters containing **GATC sequences**. Dam along with Dcm methylation can inhibit restriction enzyme cleavage; decrease transformation frequency in certain

bacteria; decrease the stability of short direct repeats; are necessary for site-directed mutagenesis; and to probe eukaryotic structure and function. Phage T4 also encodes a DAM MTase, which was found to target GATC sites and protects phage DNA from restriction endonuclease recognizing this sequence. DAM activity is essential in the regulation of E. coli cellular functions, and while **it does not appear to play a role in the lytic cycle of the T2 and T4 phage, it was found to play a role other than blocking host endonucleases in the E. coli temperate phage.**

Q.No. 36 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].

Assertion [a]: Embryonic stem cells are suitable for developing knockout mice

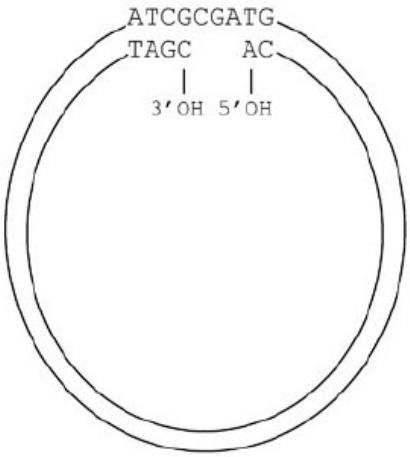
Reason [r]: Homologous recombination is more frequent in embryonic stem cells than that in somatic cells

(A) Both [a] and [r] are false
(B) Both [a] and [r] are true, and [r] is the correct reason for [a]
(C) Both [a] and [r] are true, but [r] is not the correct reason for [a]
(D) [a] is true, but [r] is false

36 B.

Details: The isolation of murine embryonic stem cells (ES) has been an important discovery necessary for the development of mice with designer mutations. Stem cells are capable of self-renewal in culture and can be maintained in an undifferentiated state under certain growth conditions. Stem cells are also totipotent and, when injected into a host blastocyst, can contribute to the somatic and germ cell lineages of the resulting chimeric mouse. If germline transmission occurs, an offspring of the chimeric mouse can be produced that was derived from the injected ES cell clone. The ability to pass on germline transmission means that a mouse can be generated from ES cells that are genetically manipulated in culture. With the discovery of homologous recombination, stem cells were seen as an ideal tool that could be used to
make genetically altered mice. Homologous recombination in stem cells was first applied for the development of knockout mice through targeted gene inactivation. Eventually, these techniques were adapted for creating conditional knockout mice, knock-in mice, and mice with subtle mutations such as genetic point mutations, deletions, and insertions.

Q. No. 37. The schematic of a plasmid with a gap in one of the strands is shown below:



Which of the following enzyme(s) is/are required to fill the gap and generate a covalently closed circular plasmid?

[P] DNA ligase

[Q] Alkaline phosphatase

[R] DNA polymerase

[S] Polynucleotide kinase

(A) P only
(B) P, R and S only
(C) P and R only
(D) P, Q and R only

37 B.

Details: **DNA ligase** is an enzyme which can connect two strands of DNA together by forming a bond between the phosphate group of one strand and the deoxyribose group on another. It is also used to join together the Okazaki fragments which are formed on the lagging strand during DNA replication.

DNA polymerase is an enzyme that synthesizes DNA molecules from deoxyribonucleotides, the building blocks of DNA. These enzymes are essential for DNA replication and usually work in pairs to create two identical DNA strands from a single original DNA molecule. During this process, DNA polymerase "reads" the existing DNA strands to create two new strands that match the existing ones. **Polynucleotide kinase** catalyses the transfer of the terminal phosphate group of ATP to the 5′-hydroxyl terminus of DNA or RNA. It also can catalyze the exchange of 5′-terminal phosphate groups. **Alkaline**

Phosphatase enzyme removes phosphate group at the 5′ end of the DNA. It is used in the modification of the adaptor molecules so as to prevent ligation of two adaptors with each other. So the correct order of using enzymes (after removing phosphate group at 5' end by alkaline phosphatase) is **Polynucleotide kinase first, then DNA polymerase and at last DNA ligase**.

Q.No. 38 Match sub-cellular organelles listed in Group I with their features listed in Group II:

Group I	Group II
[P] Mitochondrion	1. Single-membrane enclosed
[Q] Chloroplast	2. Double-membrane enclosed
[R] Nucleus	3. Maternal inheritance
[S] Endoplasmic reticulum	4. Endosymbiotic origin

(A) P-1, Q-4, R-2, S-3
(B) P-2, Q-3, R-4, S-1
(C) P-3, Q-4, R-2, S-1
(D) P-3, Q-1, R-4, S-2

38 C.

Details: In sexual reproduction, **mitochondria** are normally inherited exclusively from the mother; the mitochondria in mammalian sperm are usually destroyed by the egg cell after fertilization. The fact that mitochondrial DNA is maternally inherited enables genealogical researchers to trace maternal lineage far back in time. **Chloroplast** is one type of plastid (organelle in the plant cell). They are considered to have evolved from endosymbiotic cyanobacteria. Mitochondria are thought to have come from a similar endosymbiosis event, where an aerobic prokaryote was engulfed. The Nuclear Envelope is a double layered membrane that surrounds the **nucleus**. It consists of nuclear pores that regulate the transportation of substances such as RNA into and out of the nucleus.The nuclear envelope consists of an outer nuclear membrane and an inner membrane. Some organelles are bounded by a single membrane, for example, vacuole, lysosome, Golgi Apparatus, **Endoplasmic Reticulum**.

Q.No. 39 Which of the following strategies are used by cells for metabolic regulation?

[P] Phosphorylation - dephosphorylation

[Q] Allostery

[R] Feedback inhibition

(A) P and Q only
(B) P and R only
(C) Q and R only
(D) P, Q and R

39 D.

Details: The **phosphorylation and dephosphorylation** processes regulate the biochemical activity of many proteins. Cyclin-dependent kinases are inactivated by a combination of p21 and Thr-14/Tyr-15 phosphorylation after UV-induced DNA damage. A major area of research is the study of the regulation of the rates of metabolic pathways by **allosteric enzymes**. Regulation occurs by the binding of the effector molecules at an allosteric site (other than active site) cause conformational changes in the enzyme. **Feedback inhibition** is when a reaction product is used to regulate its own further production. Cells have evolved to use feedback inhibition to regulate enzyme activity in metabolism, by using the products of the enzymatic reactions to inhibit further enzyme activity.

Q.No. 40 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].

Assertion [a]: A zygote and its immediate descendant cells are unspecialized and are called totipotent

Reason [r]: Totipotent cells retain the capacity to differentiate into only a few cell types

(A) Both [a] and [r] are false
(B) Both [a] and [r] are true but [r] is not the correct reason for [a]
(C) Both [a] and [r] are true and [r] is the correct reason for [a]
(D) [a] is true but [r] is false

40 D.

Details: A **totipotent cell** is a single **cell** that can give rise to a new organism, given appropriate maternal support (most stringent definition) A **totipotent cell** is one that can give rise to all extraembryonic tissues, plus all tissues of the body and the germline (less stringent definition). In most animals, the only cell that is

truly totipotent is the fertilized egg — the zygote and its immediate descendants. Stem cells in an adult mammal, such as those that continually generate blood cells, give rise to a restricted spectrum of mature cell types and are considered to be merely multipotent. Many plant cells, in contrast, continue to be totipotent throughout the plant's life.

Q.No. 41 Which of the following statements about gene therapy are **CORRECT**?

[P] Affected individuals, but not their progeny, can be cured through germline gene therapy

[Q] Affected individuals, as well as their progeny, can be cured through germline gene therapy

[R] Affected individuals, but not their progeny, can be cured through somatic gene therapy

[S] Affected individuals, as well as their progeny, can be cured through somatic gene therapy

(A) P and R only
(B) P and S only
(C) Q and R only
(D) Q and S only

41 C.

Details: **Somatic cell gene therapy** involves the placement of a human gene into a living person's somatic cells—cells that do not produce the eggs and sperm that in turn produce the next generation. Somatic cell gene therapy would aim to cure a disease only in the patient, not in the patient's descendants as its genetic material is not passed over generations. **Germ line gene therapy** is the introduction of 'normal' human genes into the eggs or sperm of parents, or into the fertilized egg or early embryo of the offspring. The goal would be to change the eventual child's genetic inheritance. This could be done in order to avoid a genetic disease or in order to introduce an 'enhancing' genetic variation. There have been no trials of human germ line gene therapy; indeed, there is an informal moratorium in the scientific community on trying such experiments in humans. Both its feasibility and its value are unclear.

Q.No. 42 Determine the correctness or otherwise of the following Assertion [a] and the Reason [r].

Assertion [a]: A genetically engineered rice that produces beta-carotene in the rice grain is called Golden rice

Reason [r]: Enabling biosynthesis of provitamin A in the rice endosperm gives a characteristic yellow/orange color

(A) Both [a] and [r] are false
(B) Both [a] and [r] are true but [r] is not the correct reason for [a]
(C) Both [a] and [r] are true and [r] is the correct reason for [a]
(D) [a] is true but [r] is false

42 C.

Details: The endosperm of Golden Rice (Oryza sativa) is yellow due to the accumulation of β-carotene (provitamin A) and xanthophylls. The product of the two carotenoid biosynthesis transgenes used in Golden Rice, phytoene synthase (PSY) and the bacterial carotene desaturase (CRTI), is lycopene, which has a red color. The absence of lycopene in Golden Rice shows that the pathway proceeds beyond the transgenic end point and thus that the endogenous pathway must also be acting. Golden Rice (Oryza sativa) denotes a genetically modified rice capable of biosynthesizing and accumulating β-carotene
(provitamin A) in the endosperm, yielding a characteristic yellow color in the polished grains.

Q.No. 43 The sequence of a 1 Mb long DNA is random. This DNA has all four bases occurring in equal proportion. The number of nucleotides, on average, between two successive *EcoR*I recognition site GAATTC is _____.

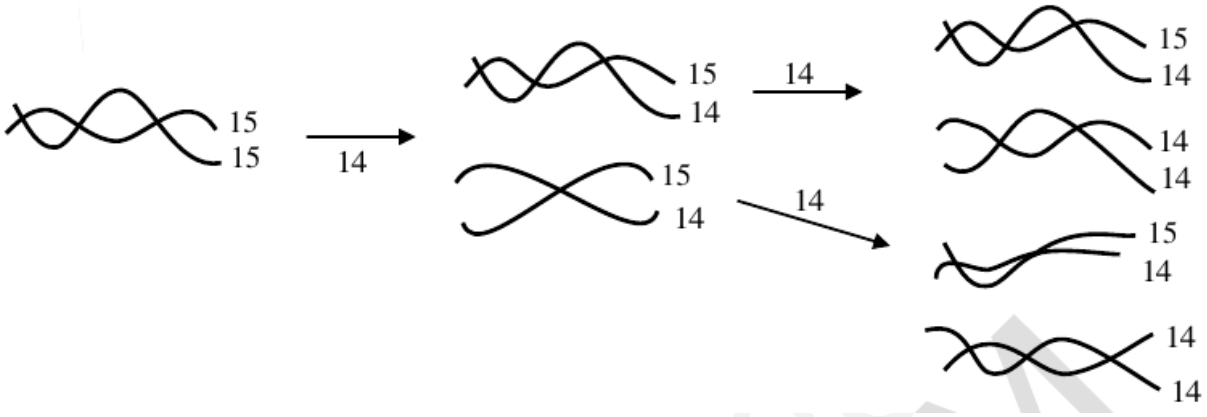
43 4096.

Details: We need to consider only one strand of DNA, because both sequences will be present on the opposite strand at the same site owing to the symmetry of the sequences. Because there are four possibilities at each of the six positions, the average number of nucleotides will be $4^6 = 4096$.

Q.No. 44 *E. coli* was grown in ^{15}N medium for several generations. Cells were then transferred to ^{14}N medium, allowed to grow for 4 generations and DNA was isolated immediately. The proportion of total DNA with intermediate density is _____ (round off to 2 decimal places).

44 0.125.

Details: See explanation through **figure**:



In four generations, there will be 16 progenies out of which two will be with the desired characteristic. So the required answer is 2/16 = 0.125.

Now with **calculative approach**:

As it is semi-conservative method so the probability is 1/2 . Now as it goes to 4 generations the probability will decrease by the same factor, that is ¼ times. So it is ½ * ¼ = ⅛ = 0.125

Q.No. 45 A batch reactor is inoculated with 1 g/L biomass. Under these conditions, cells exhibit a lag phase of 30 min. If the specific growth rate in the log phase is 0.00417 min^{-1}, the time taken for the biomass to increase to 8 g/L is _____ min (round off to 2 decimal places).

45 528.66

Details: formula of growth cycle: $\ln X_t = \ln X_0 + \mu t$ or $X_t = X_0 e^{\mu t}$

And give is: $\mu = 0.00417\ min^{-1}$, t = 30 min and $X_0 = 1$ g/L

So, $\ln 8 = \ln 1 + 0.00417 * T$

=> 2.07 = 0 + 0.00417*T

=> T= 498.66 min

498.66 + 30 (lag phase) = 528.66

Q.No. 46 The system of linear equations

$$cx + y = 5$$

$$3x + 3y = 6$$

has no solution when c is equal to _____.

46 1.

Details: $a_1x_1 + b_1y_1 = c_1$

$a_2x_2 + b_2y_2 = c_2$ has no solution if $a_1/a_2 = b_1/b_2 \neq c_1/c_2$

So, $c/3 = 1/3 \Rightarrow c = 1$

Q.No. 47 The amino acid sequence of a peptide is Phe-Leu-Ile-Met-Ser-Leu. The number of codons that encode the amino acids present in this peptide is given below:

Phe: 2 codons

Leu: 6 codons

Ile: 3 codons

Met: 1 codon

Ser: 4 codons

The number of unique DNA sequences that can encode this peptide is _____.

47 864.

Details:

2 possibilities phe	6 pos. leu	3 pos. Ile	1 pos. met	4 pos. ser	6 pos. leu

Total possibilities = 2 *6 *3 *1 * 4 * 6 = 864

Q.No. 48 Assume that a cell culture was started with five human fibroblast cells. Two cells did not divide even once whereas the other three cells completed three rounds of cell division. At this stage, the total number of kinetochores in all the cells put together is _____.

48 1196.

Details: Cells produced in "n" generations = 2^n

So 3 cells in 3 generations will produce = $3 * 2^3 = 24$ cells

So with 2 non dividing cells, culture has 26 cells.

For 23 pairs of chromosome, there are 46 (= 2*23) kinetochores (1 kinetochore per chromosome in growth phase while in metaphase stage it is double the number of chromosomes). So, Total #kinetochore = 46 * 26 = 1196

Q.No. 49 Growth of an organism on glucose in a chemostat is characterized by Monod model with specific growth rate = 0.45 h^{-1} and K_s = 0.5 g/L. Biomass from the substrate is generated as Y_{XS} = 0.4 g/g. The chemostat volume is 0.9 L and media is fed at 1 L/h and contains 20 g/L of glucose. At steady state, the concentration of biomass in the chemostat is _____ g/L.

49 0.

Details: Dilution rate is the addition of media to 1 litre of existing media and specific growth rate period is the rate of increase of biomass of a cell population per unit of biomass concentration. As at steady state, the specific growth rate, μ of the microorganism is equal to the dilution rate D.

And D=F/V.

So, D = 1/0.9 = 1.1 h^{-1}

But given μ = 0.45 h^{-1}, hence μ ≠ D.

$\mu = \mu_{max}.S/Ks+S$

Given S= 20 g/l, Ks = 0.5 g/l

So, 0.5 = μ_{max}.20/20.5 => μ_{max} = 0.5125 g/l

So, D calculated is higher than μ_{max}, Such that it exceeds D_{crit}. So it results in washout. Hence the concentration of biomass will be 0.

Q.No. 50 A function *f* is given as:

$$f(X) = 4X - X^2$$

The function *f* is maximized when X is equal to _____.

50 2.

Details: Given, $f(X) = 4X - X^2$

At maximum f(X), df/dX = 0 and $d^2f/dX^2 < 0$. So, f'(X) = 0 [f'(X) = df(X)/dX]

=> d(4X)/dX - d(X^2)/dX = 0 => 4 - 2X = 0 => X = 2.

f''(X) = d(4)/dX - d(2X)/dX => f''(X) = -2, which is less than 0.

So, the maximum value of f(X) = 2.

Q.No. 51 An infinite series *S* is given as:

$S = 1 + 2/3 + 3/9 + 4/27 + 5/81 + \ldots$ (to infinity)

The value of *S* is _____ (round off to 2 decimal places).

51 2.25.

Details:

The sequence of numerators is 1, 2, 3, 4, 5...., which has nth term n.
The sequence of denominators is 1, 3, 9, 27, 81, ..., which has nth term 3n.

So the series we want has nth term = $\frac{n}{3^n}$ = n * $(1/3)^n$

We want the infinite sum, $S=\sum_{n=0}^{\infty} n\frac{1}{3}^n$

So, start with the geometric series formula, $\sum_{n=0}^{\infty} ar^n=\frac{a}{1-r}$

Substitute a=1, $\sum_{n=0}^{\infty} r^n=\frac{1}{1-r}$

Differentiate both sides with respect to r:

$\sum_{n=0}^{\infty} nr^{n-1}=-(1-r)^{-2}(-1)$ => $\sum_{n=0}^{\infty} nr^{n-1}=\frac{1}{(1-r)^2}$

Substitute r = 1/3,

$\sum_{n=0}^{\infty} n(\frac{1}{3})^{n-1}=\frac{1}{(1-\frac{1}{3})^2}$ => $\sum_{n=0}^{\infty} n(\frac{1}{3})^{n-1}=\frac{1}{(\frac{2}{3})^2}$ => $\sum_{n=0}^{\infty} n(\frac{1}{3})^{n-1}=\frac{9}{4}$

Q.No. 52 Protein A and protein B form a covalent complex. Gel filtration chromatography of this complex showed a peak corresponding to 200 kDa. SDS-PAGE analysis of this complex, with and without beta-mercaptoethanol, showed a single band corresponding to molecular weight 50 and 25 kDa, respectively. Given that the molecular weight of protein A is 25 kDa, the molecular weight of protein B is _____ kDa.

52 25 kDa.

Details: As single band is obtained even after using **β**-mercaptoethanol (assuming A and B is separated using **β**-mercaptoethanol) so both molecules have same molecular mass i.e., 25 kDa. Results in chromatography show proteins are multimeric.

Q.No. 53 The concentrations of ATP, ADP and inorganic phosphate in a cell are 2.59, 0.73 and 2.72 mM, respectively. Under these conditions, free energy change for the synthesis of ATP at 37 °C is _____ kJ/mol (round off to 2 decimal places).

Given: free energy change for ATP hydrolysis under standard conditions is -30.5 kJ/mol and R = 8.315 kJ/mol.K

53 18521.2 kJ/mol.K.

Details: ATP ⟷ ADP + Pi

Conc. 2.59 0.73 2.72 (in mM) [require conversion to get answer]

$$\Delta G = \Delta G_0 + RT \ln \left\{ \frac{[ATP]}{[ADP]\,[Pi]} \right\}$$

$$\Rightarrow \Delta G = 30 + 8.315 * 310 \ln \left[\frac{2.59}{0.73 * 2.72} \right]$$

$$\Rightarrow \Delta G = 18521.2 \text{ kJ/mol.K}$$

Since -30 is for ATP hydrolysis and we are assuming reverse reaction, so it is positive in equation.

Q.No. 54 An algorithm was designed to find globins in protein sequence databases. A database which has 78 globin sequences was searched using this algorithm. The algorithm retrieved 72 sequences of which only 65 were globins. The sensitivity of this algorithm is _____ % (round off to 2 decimal places).

54 83.33.

Details:

$$\text{Sensitivity} = \frac{\text{Number of globins retrieved from algorithm}}{\text{Total number of globin sequences in database}} \times 100$$

$$= \frac{65}{78} \times 100 = 83.33$$

Q.No. 55 The mitochondrial electron transfer chain oxidizes NADH with oxygen being the terminal electron acceptor. The redox potentials for the two half-reactions are given below:

$$NAD^+ + H^+ + 2e^- \rightarrow NADH, E^{0\prime} = -0.32V$$

$$\frac{1}{2}O_2 + 2H^+ + 2e^- \rightarrow H_2O, E^{0\prime} = 0.816V$$

The free energy change associated with the transfer of electrons from NADH to O_2 is _____ kJ/mol (round off to 2 decimal places).

Given: F = 96500 C/mol.

55. -219.28 kJ/mol

Details: Faraday constant, F = 96.5 KJ mol^{-1}

#electron, n = 2; $\Delta E^0 = 0.816 - (-0.32) = 1.136$ V

$\Delta G^0 = -nF\Delta E^0$

=> $\Delta G^0 = -2 * 96.5 * 1.136$

=> $\Delta G^0 = -219.28$ kJ/mol