GENERAL APTITUDE

1. Despite a string of poor performances, the chances of K.L. Rahul's selection in the team are___.

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

Key: (B)

2. The difference between the sum of the first

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

Key: (D)

Sol: Sum of the first 2n natural numbers is

$$1+2+3+.....+2^n = \frac{2(n)(2n+1)}{2} = 2n^2 + n$$

Sum of the first n odd natural numbers is

$$1+3+5+.....+2(n-1) = n^2$$

$\therefore$ Required difference is $(2n^2+n) - n^2 = n^2 + n$

$\therefore$ Option (D) is correct answer.

3. The distance between Delhi and Agra is 233km. 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 10km/hr more than the speed of car Q. How many kilometers the car Q had travelled when the cars crossed each other?

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

Key: (D)

Sol: Given data is

$$\text{Delhi} \xrightarrow{233\,\text{km}} \text{Agra}$$
$$P \rightarrow \qquad \leftarrow Q$$

It is given that car P and Q crossed each other 75 minutes after the car Q started.

Let x be the distance (in km) covered by Q in 75 minutes

Hence speed of car $Q = \dfrac{x}{\frac{75}{60}}\text{km/hr} = \dfrac{4x}{5}\text{km/hr}$

So the distance covered by car P till the point of crossing is (233–x) km it is given that speed of car P is 10 km more than Q.

$\therefore$ Speed of car $P = \frac{4x}{5} + 10\,\text{km/hr}$ and this distance has been covered by car P in 1 hour and 75 min which is $\frac{9}{4}$ hour

Therefore $233 - x = \frac{9}{4}\left(\frac{4x}{5} + 10\right)$

Solving above, we get x = 75.2 km

4. Select the word that fits the analogy:

Cover: Uncover:: Associate:____

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

Key: (B)

5. 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) to, at (B) on, at (C) On, in (D) With, at

Key: (A)

6. For a matrix M = $\left[m_{ij}\right]; i, j = 1, 2, 3, 4,$ the diagonal elements are all zero and $m_{ij} = -m_{ji}$. The minimum number of elements required to fully specify the matrix is_____.

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

Key: (C)

Sol: Since all 4 diagonal elements are '0'

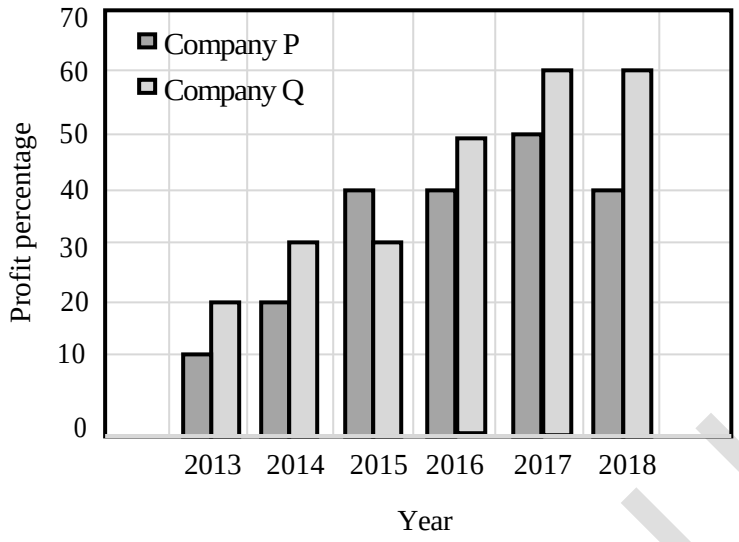
Number of non-diagonal elements is 12.

Since, $m_{ji} = -m_{ji} \Rightarrow$ Matrix M is skew symmetric

$\therefore$ Half of the 12 elements i.e., 6 elements are required to fully specify the matrix

$\therefore$ Option (C) is correct answer.

7. 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

Key: **(B)**

Sol: Suppose Rs x (amount) invested every year by Company P, and Company Q, then the total revenue by P from 2013-2018 is

$$\frac{x}{100}\times[110+120+140+140+150+140]=8x.$$

And the total revenue by Q company from 2013-2018 is

$$\frac{x}{100}\times[120+130+130+150+160+160]=\frac{85x}{10}=\frac{17x}{2}$$

$\therefore$ Required ratio is $8x:\frac{17x}{2}\Rightarrow 16:17$

8. 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 neighbor of S.

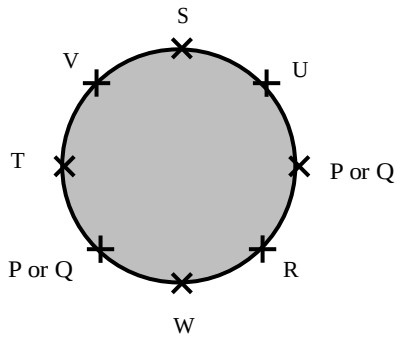
Which of the following must be true?

(A) P is not seated opposite to Q (B) R is the left neighbor of S

(C) Q is a neighbor of **R.** (D) P is a neighbor of R

Key: **(A)**

Sol: From the given data, we have the following diagram



∴ P is not seated opposite to Q.

9. 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 decrease cost of borrowing and increase lending by commercial banks.

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

(C) Increase in repo rate will decrease cost of borrowing and decrease lending by commercial banks.

(D) Increase in repo rate will increase cost of borrowing and Increase lending by commercial banks.

Key: (A)

10. 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 want the food-grain production target to be met by the November-February period.

(B) Officials feel that the food-grain production target cannot be met due to floods.

(C) Officials declared that the food-grain production target will be met due to good rains.

(D) Officials hope that the food-grain production target will be met due to good rabi produce.

Key: (D)

BIOTECHNOLOGY

Q. No. 1-25 Carry One Mark Each

1. Determine the correctness or otherwise 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 false.

(B) [a] is true but [r] is false.

(C) Both [a] and [r] are true and [r] is the correct reason for [a].

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

Key: (B)

Sol: Total calcium concentration is in mM inside cells, however, in the cytosol of most cells, the concentration of free calcium is about 10,000-fold lower. Also, within cells, calcium is complexed by inorganic compounds and low molecular weight organic molecules. However, they normally bind calcium with low affinity, and cannot lower its free concentration to the nM range, which is needed for Ca2+ to efficiently perform its signaling function.

2. Which of the following types of molecules act as biological catalysts?

[P] Protein

[Q] RNA

[R] Phospholipid

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

Key: (C)

Sol: 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.

3. During a positive-negative selection process, transformed animal cells expressing _____are killed in presence of ganciclovir in the medium.

(A) viral serine/threonine kinase

(B) viral thymidine kinase

(C) pyruvate kinase

(D) viral tyrosine kinase

Key: (B)

Sol: Discovery of new cancer biomarkers and advances in targeted gene delivery mechanisms have made gene-directed enzyme prodrug therapy (GDEPT) an attractive method for treating cancer. Recent focus has been placed on increasing target specificity of gene delivery systems and reducing toxicity in non-cancer cells in order to make GDEPT viable. The enzymatic switch was derived from the herpes simplex virus thymidine kinase (HSV-TK) fused to the CH1 domain of the p300 protein. The CH1 domain binds to the C-terminal transactivation domain (C-TAD) of the cancer marker hypoxia inducible factor 1α. The identified switch, dubbed TICKLE (Trigger-Induced Cell-Killing Lethal-Enzyme), confers a 4-fold increase in AZT toxicity in the presence of C-TAD.

4. Which one of the following media components is used to maintain pH in mammalian cell culture?

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

Key: (D)

Sol: Sodium bicarbonate is a buffer used to stabilize pH. Cells in culture produce CO2 but require only small amounts of the compound for growth and survival. CO2 affects the pH of medium. Increasing atmospheric CO2 decreases the pH of the medium.

5. Vincristine and vinblastine, two commercially important secondary metabolites from Catharanthus roseus, are examples of

(A) Steroids (B) Flavonoids (C) terpenoids (D) alkaloids

Key: (D)

Sol: Around the same time, scientists working at the drug company Eli Lilly were also searching for new drugs in the leaves of periwinkle plants. Their much larger-scale brute force screening technique turned up two promising candidate that they named vincristine and vinblastine. These chemicals are collectively referred to as vinca alkaloids, after the plant's original Latin name Vinca rosea.

6. 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).

Key: (0.5)

7. A vector derived from which one of the following viruses is used for high frequency genomic integration of a transgene in animal cells?

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

Key: **(C)**

Sol: lentiviral vectors (LVs) are used to generate transgenic animals. Although lentiviruses belong to the large family of retroviruses, they differ in several important aspects from the previously used prototypic retroviruses. LVs have been used to transfer genes into delicate cells such as stem cells, neurons and rodent embryos. In comparison with microinjection of DNA, lentiviral gene transfer results in a 27-fold higher yield in transgenic animals expressing the transgene per treated embryo. Furthermore, by incorporating specific promoters into the LVs, showed that the transgene is present in germline cells, which is the basis for its transmission to offspring. The high efficacy of lentiviral transgenesis is of great interest to academic and industrial researchers alike. This study has paved the way for the creation of the next generation of transgenic animals that express 'real' transgenes that confer a specific gene function, or of short interfering RNAs that diminish gene expression. Wild-type lentiviruses have a genome of about 8 kb, and the genetic load of LVs (comprising the internal promoter, transgene and enhancer elements) should therefore be less than this. Nevertheless, LVs carrying large and complex complementary DNAs together with proper regulatory elements have been engineered and used successfully to express therapeutic levels of the protein in animal models for the study of human disease, or as a resource for the production of therapeutic proteins or organs.

8. The largest eigenvalue of the matrix $\begin{bmatrix} 4 & 1 \\ -2 & 1 \end{bmatrix}$ is_____.

Key: **(3)**

Sol: Given matrix is $\begin{bmatrix} 4 & 1 \\ -2 & 1 \end{bmatrix}$

The characteristic equation of matrix is $\lambda^2 - 5\lambda + 6 = 0$

$$\Rightarrow \lambda^2 - 3\lambda - 2\lambda + 6 = 0$$
$$\Rightarrow \lambda(\lambda - 3) - 2(\lambda - 3) = 0$$
$$\Rightarrow (\lambda - 3)(\lambda - 2) = 0$$
$$\Rightarrow \lambda = 2, 3$$

$\therefore$ The largest eigen value is '3'.

9. 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) Ion-exchange chromatography

(B) Denaturing polyacrylamide gel electrophoresis

(C) Nickel affinity chromatography

(D) Size-exclusion chromatography

Key: (A)

Sol: Ion exchange protein purification is possible because most proteins bear nonzero net electrostatic charges at all pHs except at pH=pI (isoelectric point). At a pH >pI of a given protein, that protein becomes negatively charged (an anion), at the pH<pI of that same protein, it becomes positively charged (a cation). Ion exchange chromatography occurs due to electrostatic attraction between buffer-dissolved charged proteins and oppositely charged binding sites on a solid ion exchange adsorbent. An ion exchange adsorbent (also called media, resin, gel, or matrix) usually consists of spherical porous inert beads with charged groups (functional groups) densely grafted onto the beads' surfaces; the charges of functional groups are neutralized by free counter-ions. Ion exchange chromatography columns bind proteins with a negative net-charge. At a pH above its isoelectric point, your protein has a negative net charge and will bind to an anion exchanger. The His-tag of the proteins do not have any affinity.

10. Ras protein is a

(A) Monomeric GTPase involved in relaying signal form cell suface to nucleus

(B) trimeric 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.

Key: (A)

Sol: The Ras protein is a monomeric globular protein of 189 amino acids (21 kDa molecular mass) which is associated with the plasma membrane and which binds either GDP or GTP. With GTP bound, Ras is "switched on" and is able to interact with and activate other proteins (its "downstream targets").The Ras protein is involved in transmitting signals within cells (cellular signal transduction).

11. 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, Q and R

(D) P and R only

Key: (C)

Sol: Epstein-Barr virus, human papilloma virus, hepatitis B virus, and human herpes virus-8 are the four DNA viruses that are capable of causing the development of human cancers. Human T lymphotrophic virus type 1 and hepatitis C viruses are the two RNA viruses that contribute to

human cancers. MicroRNAs (miRNAs) are endogenous, small non-coding RNAs that function in regulation of gene expression. MiRNAs may function as either oncogenes or tumor suppressors under certain conditions. The dysregulated miRNAs have been shown to affect the hallmarks of cancer, including sustaining proliferative signaling, evading growth suppressors, resisting cell death, activating invasion and metastasis, and inducing angiogenesis. An increasing number of studies have identified miRNAs as potential biomarkers for human cancer diagnosis, prognosis and therapeutic targets or tools, which needs further investigation and validation. Mainly, miRNAs regulate the development of human tumors and cancers with changes in their levels. In general, cancer-related genes can be divided into two broad classes, proto-oncogenes and tumor suppressor genes (TSGs). Proto-oncogenes are generally involved in pathways that promote cellular growth. These genes can cause normal cells to become cancerous when they are activated by mutations or alterations. Mutations in proto-oncogenes are typically dominant in nature, and the mutated versions of these genes are known as oncogenes. TSGs is considered as another kind of crucial genes, which are involved in DNA damage repair, inhibition of cell division, induction of apoptosis, and suppression of metastasis. Therefore, loss of TSGs function would result in the onset and progression of cancer and these tumor suppressor genes can be off without any change in dna sequence.

12. The number of molecules of a nucleotide of molecular weight 300 g/mol present in 10 picomoles is_____x10^{12} (round off to 2 decimal places).

Key: $(\mathbf{6.02})$

Sol: Given,

Molecular weight = 300g/mol

Number of moles = 10 picomoles

$$=10\times10^{-12}\text{ mol}$$

Number of moles $=10^{-11}$ mol

Number of nucleotide molecules = number of moles × Avogadro number

$$=10^{-11}\times6.022\times10^{23}$$

$$=6.022\times10^{12}$$

$$=6.02\times10^{12}$$

13. 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) [a] is false but [r] is true

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

(C) Both [a] and [r] are false

(D) Both [a] and [r] are true and [r] is the correct reason for [a]

Key: **(D)**

Sol: The cytochrome complex is a small hemeprotein found loosely associated with the inner membrane of the mitochondrion. It belongs to the cytochrome c family of proteins and plays a major role in cell Apoptosis. Cytochrome c is highly water-soluble, unlike other cytochromes, and is an essential component of the electron transport chain, where it carries one electron. It is capable of undergoing oxidation and reduction as its iron atom converts between the ferrous and ferric forms, but does not bind oxygen. It transfers electrons between Complexes III (Coenzyme Q – Cyt C reductase) and IV (Cyt C oxidase). In humans, cytochrome c is encoded by the *CYCS* gene. Cytochrome c belongs to class I of the c-type cytochrome family and contains a characteristic CXXCH (cysteine-any-any-cysteine-histidine) amino acid motif that binds heme.This motif is located towards the N-terminus of the peptide chain and it contains a histidine as the fifth ligand of the heme iron. The sixth ligand is provided by a methionine residue found towards the C-terminus. The protein backbone is folded into five α-helices that are numbered α1-α5 from N-terminus to C-terminus. Helices α3, α4 and α5 are referred to as 50s, 60s and 70s helix respectively when referring to mitochondrial cytochrome c.

14. Which one of the following statements about Agrobacterium Ti plasmid is CORRECT?

(A) Opine catabolism genes are located within the T-DNA segment

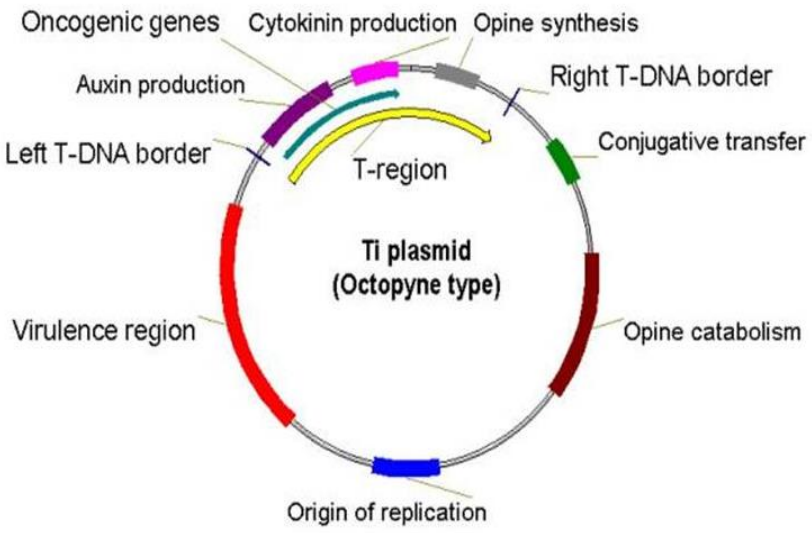
(B) Vir genes are located within the T-DNA segment

(C) Phytohormone biosynthesis genes are located outside the T-DNA segment

(D) Opine biosynthesis genes are located within the T-DNA segment

Key: **(D)**

Sol:



15. DNA synthesized from an RNA template is called

(A) Complementary DNA

(B) transcript

(C) T-DNA

(D) recombinant DNA

Key: **(A)**

Sol: In genetics, complementary DNA (cDNA) is DNA synthesized from a single-stranded RNA (e.g., messenger RNA (mRNA) or microRNA (miRNA)) template in a reaction catalyzed by enzyme reverse transcriptase. cDNA is often used to clone eukaryotic genes in prokaryotes. When scientists want to express a specific protein in a cell that does not normally express that protein (i.e., heterologous expression), they will transfer the cDNA that codes for the protein to the recipient cell. 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.

16. Which of the following area energy transducing membranes?

P. Plasma membrane of bacteria

Q. Inner membrane of chloroplasts

R. Inner membrane of mitochondria

(A) P and R only

(B) P, Q and R

(C) P and Q only

(D) Q and R only

Key: **(A)**

Sol: The ATP synthesis in energy transducing membranes of mitochondria is analyzed as an energy coupling between energy-donating and energy-accepting chemical reactions. This coupling in realized by the special enzyme, ATP synthase, functioning in essentially nonequilibrium state as a kind of molecular machine. It follows from the principal possibility of ATP formation from ADP and Pi after fast enzyme local perturbation, i.e., deprotonation of certain acid groups, not only by membrane-bound ATP synthases but also by the isolated ATPases of various origin. Closed membrane vesicles of mitochondria are necessary only for the cyclic functioning of ATP synthase during the steady state ATP synthesis. The energy transducing membranes are the plasma membrane of prokaryotic bacteria and blue-green algae, the inner membrane of mitochondria, and the thylakoid membrane of chloroplasts. The ATP synthase, called the proton-translocating ATPase, is present in closely similar forms in all energy-transducing membranes.

17. Protein P becomes functional upon phosphorylation of a serine residue. Replacing this serine with _____will result in a phosphomimic mutant of P.

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

Key: (D)

Sol: Serine is often mutated to glutamic acid (sometimes 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. 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.

18. 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).

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

Key: (51.27)

Sol: Given,

Atomic Weight, C = 12

H = 1

N = 14

O = 16

P = 31

S = 32

$$\text{Contribution of Carbon} = \frac{\text{Atomic weight of carbon}}{\text{Atomic weight of Biomass}} \times 100$$

$$= \frac{12 \times 100}{12 + (1.6 \times 1) + (16 \times 0.4) + (14 \times 0.2) + (0.0024 \times 32) + (0.017 \times 31)}$$

$$= \frac{1200}{23.4038} = 51.27\%$$

19. 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_____.

Key: **(8)**

Sol: Given,

Radius of Bubble = r

After bubble breaks into 8 bubbles, new radius = $\frac{r}{8}$

Ratio of interfacial surface area to gas phase volume $= \frac{3/r}{3n/r}$

$$\frac{\frac{4\pi r^2}{\pi r^3/3}}{\frac{4\pi\left[\frac{r}{8}\right]^2}{\frac{\pi}{3}\left(\frac{r}{8}\right)^3}} = \frac{3}{3n}$$

$$\frac{4\pi r^2}{\frac{\pi}{3}r^3} \times \frac{\frac{\pi}{3}\left(\frac{r}{8}\right)^3}{4\pi\left[\frac{r}{8}\right]^2} = \frac{1}{n}$$

$$\frac{1}{r} \times \frac{r^3}{8^3} \times \frac{8^2}{r^2} = \frac{1}{n}$$

$$\frac{1}{r} \times \frac{r}{8} = \frac{1}{n} \Rightarrow n = 8$$

20. 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).

Key: **(2)**

Sol: $Z = x^2 + y^2$

$$\Rightarrow \frac{\partial Z}{\partial x} = 2X + 0 = 2X$$

$$\Rightarrow \frac{\partial Z}{\partial X} \text{ for } X = 1 \text{ is '2'}$$

21. 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 _____.

Key: **(1)**

22. A function f is as follows:

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

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

Key: **(15)**

Sol: The function 'f' to be continuous,

$$\lim_{x\to 1} f(x)=f(1)\Rightarrow \lim_{x\to 1} f(x)=c \quad ...(1) \qquad \begin{pmatrix} Q\ f(x)=cx \text{ if } x=1\\ \Rightarrow f(1)=c.1=c\end{pmatrix}$$

$\therefore \lim_{x\to 1^-} f(x)=\lim_{x\to 1^-} 15=15 \rightarrow$ Left hand limit at x=1

$\therefore \lim_{x\to 1^+} f(x)=\lim_{x\to 1^+} cx=c.1=c \rightarrow$ Right hand limit at x=1

$\therefore$ If $c=15$ then limit exists

$\therefore$ From (1), $\lim_{x\to 1} f(x)=c=15$

23. A microorganism isolated from a salt-rich (salt concentration ~2M) 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) an archaea
(B) a planctomycete
(C) a unicellular amoeba
(D) a cyanobacteria

Key: **(A)**

Sol: The extremely stable biomolecules manufactured by organisms from extreme environments are of great scientific and engineering interest in the development of robust and stable industrial biocatalysts. Identification of molecules that impart stability under extremes will also have a profound impact on our understanding of cellular survival. This isolation and characterization of archaea tetraethers as well as target technologies for tetraether lipid application. The isolation and characterization of archaea, isolated from salt rich lake which possess diglycerol tetraethers with polyisoprenoid side chains as major lipid component of its cell wall. The tetraether lipids has led to some interesting applications improving on ester lipid technologies. Potential applications include novel lubricants, gene-delivery systems, monolayer lipid matrices for sensor devices, and protein stabilization.

24. Which class of antibody is first made by developing B cells inside bone marrow?

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

Key: **(A)**

Sol: IgM is not only the first class of antibody to appear on the surface of a developing B cell. It is also the major class secreted into the blood in the early stages of a primary antibody response, on first exposure to an antigen.

25. 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.

Key: **(60)**

Sol: Let us consider the amount of solute in solvent B phase = 'a' gram

Given that the solute is 1.5 times more soluble in solvent A.

Hence, amount of solute in solvent A phase = 1.5a.

$$a + 1.5a = 100$$

Therefore $2.5a = 100$

$$a = \frac{100}{2.5} = 40$$

Now amount of solute in solvent A phase – 1.5a = $1.5 \times 40 = 60$

Q. No. 26-55 Carry Two Marks Each

26. An infinite series S is given as:

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

The value of S is_____(round off to 2 decimal places).

Key: **(0.75)**

Sol: $S = \frac{1}{1} + \frac{2}{3} + \frac{3}{9} + \frac{4}{27} + \frac{5}{81} + ... + \alpha$

$$S = \frac{1}{3^0} + \frac{2}{3^1} + \frac{3}{3^2} + \frac{4}{3^3} + \frac{5}{3^4} + ... + \infty$$

$$S = \sum_{n=0}^{\infty} n\left(\frac{1}{3}\right)^n$$

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

For $a = 1 \Rightarrow \sum_{n=0}^{\infty} r^n = \frac{1}{1-r} = (1-r)^{-1}$

Differentiating w.r.t r

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

Substitute $r = \frac{1}{3}$

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

Putting $n = n-1+1$

$$\sum_{n=0}^{\infty} .((n-1)+1)\left(\frac{1}{3}\right)^{n-1} = \frac{9}{4}$$

$$\sum_{n=0}^{\infty} (n-1).\left(\frac{1}{3}\right)^{n-1} + \left(\frac{1}{3}\right)^{n-1} = \frac{9}{4}$$

$$\sum_{n=0}^{\infty} (n-1)\left(\frac{1}{3}\right)^{n-1} + \sum_{n=0}^{\infty}\left(\frac{1}{3}\right)^{n-1} = \frac{9}{4}$$

Put $n-1 = k \Rightarrow n = 1+k$

$$\sum_{k+1=0}^{\infty} (k+1-1)\left(\frac{1}{3}\right)^{k+1-1} + \sum_{k+1=0}^{\infty}\left(\frac{1}{3}\right)^{k+1-1} = \frac{9}{4}$$

$$\sum_{k=-1}^{\infty} k\left(\frac{1}{3}\right)^{k} + \sum_{k=-1}^{\infty}\left(\frac{1}{3}\right)^{k} = \frac{9}{4}$$

$$-1\left(\frac{1}{3}\right)^{-1} + \sum_{n=0}^{\infty} n\left(\frac{1}{3}\right)^{n} + \left(\frac{1}{3}\right)^{-1} + \sum_{n=0}^{\infty}\left(\frac{1}{3}\right)^{n} = \frac{9}{4}$$

$$\sum_{n=0}^{\infty} n\left(\frac{1}{3}\right)^{n} + \sum_{n=0}^{\infty}\left(\frac{1}{3}\right)^{n} = \frac{9}{4}$$

$$\frac{a}{1-r} = \frac{1}{1-\frac{1}{3}} = \frac{3}{2}$$

$$\sum_{n=0}^{\infty} n\left(\frac{1}{3}\right)^{n} + \frac{3}{2} = \frac{9}{4}$$

$$\sum_{n=0}^{\infty} n.\left(\frac{1}{3}\right)^{n} = \frac{9}{4} - \frac{3}{2} = \frac{3}{4} = S$$

27. 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 EcoRI recognition site GAATTC is _____.

Key: **(4096)**

Sol: 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 $4^6 = 4096$.

28. 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'CGGAAATTCAGATCTTAG3' and 5' GCGCTACATTATTGCCCA3'

(B) 5'GCTTAGATCTGAATTTTC3' and 5' TGGGCAATAATGTAGCGC3'

(C) 5'GCTAAGATCTGAATTTTC3' and 5' GCGCTACATTATTGCCCA3'

(D) 5'GGAAATTCAGATCTTAGT3' and 5' TGGGCAATAATGTAGCGC3'

Key: **(C)**

Sol: The forward primers need to bind to the 3' end of the bottom strand and so is identical to the top strand. That means the hypothetical forward primer would be GCTAA. Because primers are read and created by humans our reverse primer need to be written from the beginning to the end. This is called the "reverse complement" of the top strand. The 4 bases that bind to the 3' of the top strand are TCGCG. But remember that the primer starts at the 3' end so it should be read as GCGCT. This is the reverse complement, the reverse of the opposite of the top strand. Option (3) shows the correct set of the forward and reverse primers.

29. Growth of an organism on glucose in a chemostat is characterized by Monod model with specific growth rate $= 0.45h^{-1}$ 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 glucose. At steady state, the concentration of biomass in the chemostat is _____ g/L.

Key: **(8.34)**

Sol: Given,

Specific growth rate $\mu_m = 0.45h^{-1}$

$K_s = 0.5g/L, \quad Y_{x/s} = 0.4g/g$

V=0.9L, F=1L/hr

$S_0 = 20g/L$

$F = DV$

$$D = \frac{F}{V} = \frac{1}{0.9} = 1.111 hr^{-1}$$

$$X = (S_o - S_F) Y_{x/s} = \left\{ 20 - \left[\frac{K_s D}{\mu_m - D} \right] \right\} Y_{x/s}$$

$$= \left[20 - \left(\frac{0.5 \times 1.111}{0.45 - 1.111} \right) \right] 0.4 = 8.34 g/L$$

30. 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=8.315kJ/mol.K.

Key: (18521.25)

Sol: Given,

Concentration of $ATP = 2.59 mM = 2.59 \times 10^{-3} M$

Concentration $ADP = 0.73 mM = 0.73 \times 10^{-3} M$

Concentration of $P_i = 2.72\ mM = 2.72 \times 10^{-3} M$

$T = 37°C = 37 + 273 = 310K$

$\Delta G° = -30.5\ kJ/mol \quad (\text{For ATP hydrolysis})$

For ATP Biosynthesis

$ADP + P_i \rightarrow ATP$

$\Delta G° = +30.5\ kJ/mol$

$$\Delta G = \Delta G° + RT \ln \left[\frac{[ATP]}{[ADP][P_i]} \right]$$

$$= 30.5 + 8.315 \times 310 \ln \left[\frac{2.59 \times 10^{-3}}{0.73 \times 10^{-3} \times 2.72 \times 10^{-3}} \right]$$

$$= 30.5 + 8.315 \times 310 \ln [1304.39]$$

$$= 30.5 + 18490.75$$

$$\Delta G = 18521.25\ kJ/mol$$

31. 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 true, and [r] is the correct reason for [a]

(B) [a] is true, but [r] is false

(C) Both [a] and [r] are false

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

Key: (A)

Sol: 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.

32. 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).

Key: (–219.25)

Sol: Given, $F = 96500\ C/mol$

$F = 96.5\ kC/mol$

$n = 2(2 \text{ electrons are transferred})$

$\Delta E° = 0.816 - (-0.32)$

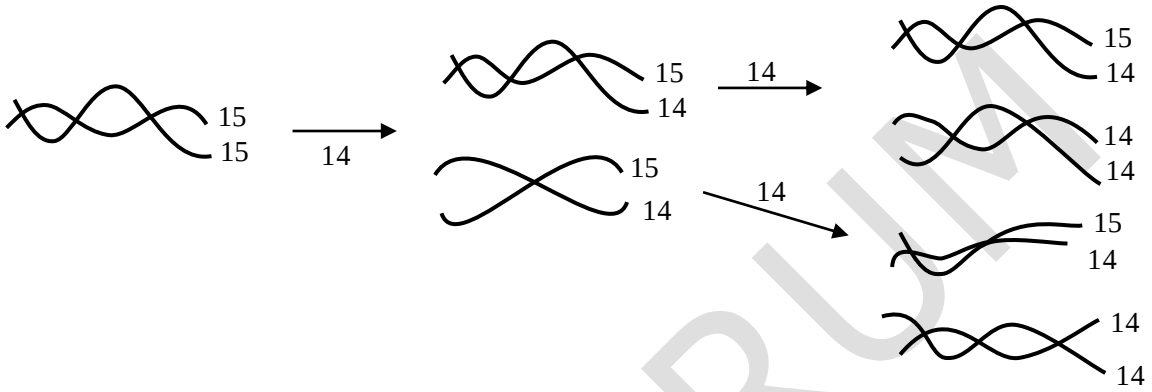
$\Delta E° = 1.136V$

$\Delta G = -nF\Delta E° = -2 \times 96.5 \times 1.136 = -219.25\ kJ/mol$

33. E. coli was grown n ^{15}N medium for several generations. Cells were then transferred 10 ^{14}N medium, allowed to grow for 4generations and DNA was isolated immediately. The proportion of total DNA with intermediate density is _____ (round off to 2 decimal places).

Key: **(0.125)**

Sol:



Similarly, 2 out of every 16 will has (15-14) intermediates the proportion of total DNA with intermediate density

$$\Rightarrow \frac{2}{16} = 0.125$$

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 – 2, Q – 3, R – 1, S – 5

(B) P – 5, Q – 2, R – 4, S – 1

(C) P – 2, Q – 3, R – 4, S – 1

(D) P – 4, Q – 3, R – 2, S – 5

Key: **(C)**

Sol: Amantadine is effective against all influenza A subtypes that have previously caused disease in humans (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-induced control of Mycobacterium tuberculosis by primary human cells requires interleukin-1 receptor and tumor necrosis factor.

35. Which of the following strategies are used by cells for metabolic regulation?

P. Phosphorylation- dephosphorylation

Q. Allostery

R. Feedback inhibition

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

Key: (B)

Sol: The phosphorylation and dephosphorylation processes regulate the biochemical activity of many proteins. Active centers of some enzymes contain seryl hydroxyl groups and can be inactivated by irreversible derivatization of these groups. 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, remove from the active site, and including 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.

36. 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) $P-3, Q-1, R-4, S-2$
(B) $P-1, Q-4, R-2, S-3$
(C) $P-3, Q-4, R-2, S-1$
(D) $P-2, Q-3, R-4, S-1$

Key: (C)

Sol: 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. Chloroplasts are one of many types of organelles 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 consist 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.

37. 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_____.

Key: **(1196)**

Sol: In humans, during the cell cycle, two kinetochores are attached to spindle fibres on the opposite poles.

In humans, there are 23 pairs of chromosomes.

Number kinetochores $= N_o \times 2^n$

Given, $N_o = 3, n = 3$ (since 3 cells completed 3 rounds of cell division)

$\Rightarrow$ Number of kinetochores $= 3 \times 2^3 = 3 \times 8 = 24$

Given, 2 cells did not divide even once

$\Rightarrow$ Number of kinetochores = 24 + 2 = 26

Since two kinetochores are attached to each spindle fibres

Number of kinetochores = 26 × 2 = 52.

For 23 pairs of chromosomes

$\Rightarrow$ Total number of kinetochores = 52 × 23 = 1196

38. 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).

Key: **(528.67)**

Sol: Given, $X_o = 1 g/L$

$t_{lag} = 30$ min

$\mu_x = 0.00417, X = 8 g/L$

$$\ln \frac{X}{X_o} = \mu t_{log}$$

$$\Rightarrow t_{log} = \frac{1}{\mu} \ln \frac{X}{X_o}$$

$$t_{log} = \frac{1}{0.00417} \ln \frac{8}{1}$$

$$t_{log} = 498.67 \text{ min}$$

$$\text{Total } t = t_{Lag} + t_{Log}$$

$$t_{total} = 30 + 498.67 = 528.67$$

39. 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 beat-mercaptoethanol, showed a single band corresponding to molecular weight 50 and 25kDa, respectively. Given that the molecular weight of protein A is 25 kDa, the molecular weight of protein B is _____ kDa.

Key: **(50)**

Sol: Gel filtration chromatography seprarates proteins, peptides, and oligonucleotides on the basis of size. Molecules move through a bed of porous beads, diffusing into the beads to greater or lesser degrees. Smaller molecules diffuse further into the pores of the beads and therefore move through the bed more slowly, while larger molecules enter less or not at all and thus move through the bed more quickly. Both molecular weight and three-dimensional shape contribute to the degree of retention. Gel Filtration Chromatography may be used for analysis of molecular size, for separations of components in a mixture, or for salt removal or buffer exchange from a preparation of macromolecules. SDS-PAGE (sodium dodecyl sulfate–polyacrylamide gel electrophoresis) is a variant of polyacrylamide gel electrophoresis, an analytical method in biochemistry for the separation of charged molecules in mixtures by their molecular masses in an electric field. It uses sodium dodecyl sulfate (SDS) molecules to help identify and isolate protein molecules.

Given that both proteins A and B show peak of 200 kDa collectively. Since SDS PAGE with beta mercaptoethanol show single band of 50 kDa and without beta mercaptoethanol show single band of 25 kDa.The beta mercaptoethanol used in SDS PAGE is a reducing agent that cleaves disulphide bonds in proteins. This means A is a dimer having two subunits of 25 kDa each making it 50 kDa. Also, B is a trimer with 3 subunits of 50 kDa each.

40. 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):

Mutants	Media supplemented with			
	W	X	Y	Z
Z1	No	No	Yes	Yes
Z2	No	Yes	Yes	Yes
Z3	No	No	No	Yes
Z4	Yes	Yes	Yes	Yes

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

(A) $S \cdots\cdots \xrightarrow{Z1} W \xrightarrow{Z2} X \xrightarrow{Z3} Y \xrightarrow{Z4} Z$

(B) $S \cdots\cdots \xrightarrow{Z4} W \xrightarrow{Z1} X \xrightarrow{Z2} Y \xrightarrow{Z3} Z$

(C) $S \cdots\cdots \xrightarrow{Z4} W \xrightarrow{Z2} X \xrightarrow{Z1} Y \xrightarrow{Z3} Z$

(D) $S \cdots\cdots \xrightarrow{Z3} W \xrightarrow{Z1} X \xrightarrow{Z2} Y \xrightarrow{Z4} Z$

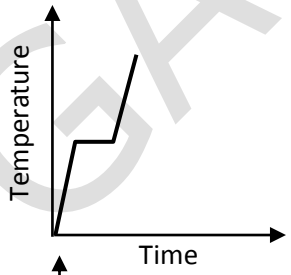
Key: (C)

Sol: For Mutant, see the row 4 and column 4 (Z) (Z4)

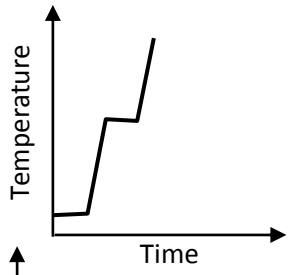
i.e., (yes) which means Z4 will be extreme left side and Z3 sequence will be extreme right due to yes for 'Z', i.e. 3 Row (Z3) and 3rd column (Z).

41. A block of ice at 0° C is supplied heat at a constant rate to convert ice to superheat 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.

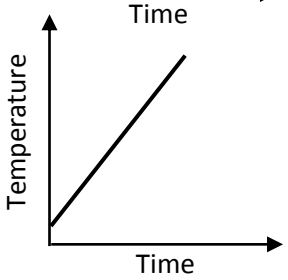
(A)



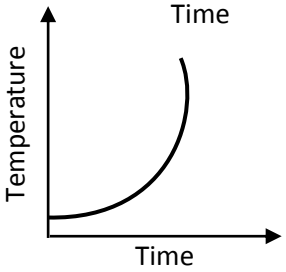
(B)



(C)

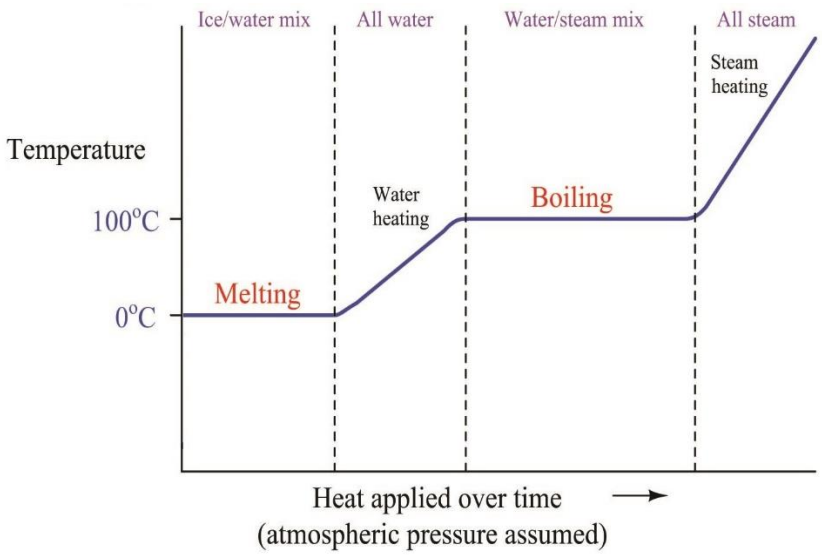


(D)



Key: (B)

Sol:



42. A function f is given as:

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

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

Key: (2)

Sol: Given, $f(x) = 4x - x^2$

$$f'(x) = 0 \Rightarrow 4 - 2x = 0$$

$$\Rightarrow x = 2$$

$$f''(x) = -2 < 0$$

$\therefore x = 2$ is a point of maximum.

43. 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 × rrpp (B) RrPp × RrPp

(C) RrPp × Rrpp (D) RrPP × Rrpp

Key: (C)

Sol: The tomato color and stem color is controlled by TWO genes. The dominant (R) allele prevents other color alleles from being expressed, so the fruit turns red. The recessive form (r) allows yellow color to be expressed. A second gene causes the stem to be either purple (P) or green(p). So for these tomatoes: Inheriting one R allele makes the fruit red regardless of any other alleles inherited.

If the tomato gets two r alleles the fruit will be yellow.

If the tomato gets the genotype RR or Rr it will be red.

Making a dihybrid Punnet square to predict the outcome of this cross. It will determine the proportion of each phenotype and how is it different from the phenotypic ratio in the first type of tomato fruit 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

Since it is given that the two genes are independently assorted, so an individual must be recessive for both genes to have a yellow phenotype, must be recessive for the purple color gene and homozygous dominant or heterozygous for the color gene to be yellow, and if it is homozygous dominant or heterozygous for the red gene, it will be red. Thus there are three phenotypic possibilities, but 16 possible allelic combinations.

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

Key: (A)

Sol: Cyclin degradation is equally important for progression through the cell cycle. Specific enzymes break down cyclins at defined times in the cell cycle. When cyclin levels decrease, the corresponding CDKs become inactive. Cell cycle arrest can occur if cyclins fail to degrade. Cyclin-dependent kinases

are inactivated by a combination of p21 and Thr-14/Tyr-15 phosphorylation after UV-induced DNA damage. The cyclin-dependent kinase (CDK) inhibitor p21 is induced by the tumor suppressor gene product p53 and is thought to be important for the arrest of the cell cycle following DNA damage.

45. 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 _____.

Key: (864)

Sol: Number of DNA sequences that encode this peptide

$$= \text{Phe} \times \text{Leu} \times \text{Ile} \times \text{Met} \times \text{Ser} \times \text{Leu}$$
$$= 2 \times 6 \times 3 \times 1 \times 4 \times 6 = 864$$

The sequence is as per given in the question.

46. 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).

Key: (83.33)

Sol: $$\text{Sensitivity} = \frac{\text{Number of globins retrieved from algorithm}}{\text{Total number of globin sequencies in database}} \times 100$$
$$= \frac{65}{78} \times 100 = 83\%$$

47. 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) P and R only (D) R and S only

Key: (C)

Sol: Synthetic cytokinin analogues such as 6-benzylaminopurine (BAP), and kinetin were examined for antioxidant activity. The compounds were tested as potential diphenylpicrylhydrazyl (DPPH) scavengers and as inhibitors of 15-lipoxygenase (15-LO). The natural plant hormones were essentially inactive in both assays, but several synthetic analogues have a profound inhibiting effect on 15-lipoxygenase from soybeans. The same compounds were only weak DPPH scavengers and they may therefore be regarded as so-called non antioxidant inhibitors of 15-LO.

48. 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 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) Q and R only (B) P and R only (C) Q and S only (D) P and S only

Key: (A)

Sol: 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. It was initially conceived as introducing a properly functioning copy of a gene into a person who had a genetic disease as a result of inheriting only improperly functioning copies. Different types of somatic cell gene therapy have since been investigated for the treatment of diseases that are not primarily caused by inherited genes, such as AIDS and cancer. Germ line gene therapy is 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.

49. 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) [a] is true but [r] is false

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

(C) Both [a] and [r] are false

(D) Both [a] and [r] are true but [r] is the correct reason for [a]

Key: (A)

Sol: Stem cells that can produce the entire spectrum of cell types found in an organism are 'totipotent'. 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 pluripotent. Many plant cells, in contrast, continue to be totipotent throughout the plant's life, i.e. plants can be propagated from small pieces of tissue or even from single cells. Totipotent cells can form all the cell types in a body, plus the extraembryonic, or placental, cells. Embryonic cells within the first couple of cell divisions after fertilization are the only cells that are totipotent.

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

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

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

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

(B) Both [a] and [r] are false

(C) Both [a] and [r] are true but [r] is the correct reason for [a]

(D) [a] is false but [r] is true.

Key: (D)

Sol: DNA methylation in bacteria is most often thought of in its role to protect DNA from restriction endonucleases and not from phage endonucleases. In addition to this role, however, studies in Escherichia coli have shown that methylated bases have other biological functions. In these cases, the methylated bases are not part of a restriction/modification system and the enzymes that produce them are often referred to as orphan or solitary DNA methyltransferases. The Dam (DNA adenine methyltransferase) enzyme, which modifies GATC sequences, forms over 99% of the 6-meAde in E. coli DNA, since strains lacking this enzyme contain only the contribution expected from the EcoK enzyme .

51. 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) Q and R only (B) P and R only (C) P, Q and R (D) P and Q only

Key: (B)

Sol: An antigen-presenting cell (APC) or accessory cell is a cell that displays antigen complexed with major histocompatibility complexes (MHCs) on their surfaces; this process is known as antigen

presentation. Tcells may recognize these complexes using their Tcell receptors (TCRs). APCs process antigens and present them to T-cells. Almost all cell types can present antigens, macrophages, B cells and dendritic cells, present foreign antigens to helper T cells. In addition to the MHC family of proteins, antigen presentation relies on other specialized signaling molecules on the surfaces of both APCs and T cells. Not only do dendritic cells, macrophages, and B cells present Foreign antigens, but they are referred to as "professional" antigen presenting cells due to their ability to present exogenous antigens using MHC II receptors. T cells are activated through T cell receptor (TCR) recognition of peptidic fragments of antigen bound to major histocompatibility complex (MHC) molecules on antigen-presenting cells (APC). In addition, T cells require a costimulatory signal delivered through contact with other ligands on APC. Under physiological conditions, T cell activation requires contact with viable APC. Under defined conditions, however, T cells can be activated by exosomes secreted by APC.

52. Carl Woese used the gene sequence of which one of the following for phylogenetic taxonomy of prokaryotes?

(A) A ribosomal protein of large ribosomal subunit

(B) A ribosomal RNA of large ribosomal subunit

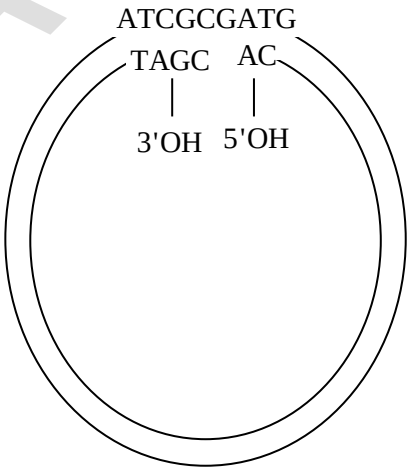
(C) A ribosomal protein of small ribosomal subunit

(D) A ribosomal RNA of small ribosomal subunit

Key: (D)

Sol: 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.

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

Key: (A)

Sol: 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 used in cells 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.

54. 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 colour.

(A) [a] is true but [r] is false

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

(C) Both [a] and [r] are false

(D) Both [a] and [r] are true but [r] is the correct reason for [a]

Key: (D)

Sol: 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.

55. The system of linear equations

$$cx + y = 5$$
$$3x + 3y = 6$$

has no solution when c is equal to _____

Key: (1)

Sol: $\left.\begin{array}{l} a_1x + b_1y = c_1 \\ a_2x + b_2y = c_2 \end{array}\right]$ has no solution if $\frac{a_1}{a_2} = \frac{b_1}{b_2} \neq \frac{c_1}{c_2}$

$\therefore \frac{c}{3} = \frac{1}{3} \neq \frac{5}{6} \Rightarrow c = 1$