Paper Specific Instructions

1. The examination is of 3 hours duration. There are a total of 60 questions carrying 100 marks. The entire paper is divided into three sections, **A**, **B** and **C**. All sections are compulsory. Questions in each section are of different types.

2. **Section A** contains a total of 30 **Multiple Choice Questions (MCQ).** Each MCQ type question has four choices out of which only **one** choice is the correct answer. Questions Q.1 – Q.30 belong to this section and carry a total of 50 marks. Q.1 – Q.10 carry 1 mark each and Questions Q.11 – Q.30 carry 2 marks each.

3. **Section B** contains a total of 10 **Multiple Select Questions (MSQ).** Each MSQ type question is similar to MCQ but with a difference that there will be **more than one** choices that are correct out of the four given choices. The candidate gets full credit if he/she selects all the correct answers only and no wrong answers. Questions Q.31 – Q.40 belong to this section and carry 2 marks each with a total of 20 marks.

4. **Section C** contains a total of 20 **Numerical Answer Type (NAT)** questions. For these NAT type questions, the answer is a real number which needs to be entered using the virtual keyboard on the monitor. No choices will be shown for these type of questions. Questions Q.41 – Q.60 belong to this section and carry a total of 30 marks. Q.41 – Q.50 carry 1 mark each and Questions Q.51 – Q.60 carry 2 marks each.

5. In all sections, questions not attempted will result in zero mark. In **Section A** (MCQ), wrong answer will result in **NEGATIVE** marks. For all 1-mark questions, 1/3 marks will be deducted for each wrong answer. For all 2-mark questions, 2/3 marks will be deducted for each wrong answer. In **Section B** (MSQ), there is **NO NEGATIVE** and **NO PARTIAL** marking provisions. There is **NO NEGATIVE** marking in **Section C** (NAT) as well.

6. Only Virtual Scientific Calculator is allowed. Charts, graph sheets, tables, cellular phone or other electronic gadgets are **NOT** allowed in the examination hall.

7. A Scribble Pad will be provided for rough work.

Special Instructions / Useful Data

Section A: Q.1 – Q.10 Carry ONE mark each.

Q.1 The porphyrin ring (tetrapyrrole structure) is NOT found in functional

(A) chlorophyll

(B) hemoglobin

(C) hemocyanin

(D) leghemoglobin

Q.2 If $P = \begin{pmatrix} cos\alpha & sin\alpha \\ -sin\alpha & cos\alpha \end{pmatrix}$ and $P + P^T = I$, the value of α $(0 \leq \alpha \leq \pi/2)$ is

(A) $\frac{\pi}{2}$

(B) $\frac{\pi}{3}$

(C) $\frac{3\pi}{2}$

(D) 0

Q.3 After how many cycles of polymerase chain reaction (PCR), the amplified product of required length is generated for the first time from a chromosomal DNA template?

(A) 2

(B) 3

(C) 4

(D) 5

Q.4 In humans, Down syndrome is caused by

(A) Trisomy 16

(B) Trisomy 18

(C) Trisomy 21

(D) Trisomy 22

Q.5 Which one of the following hormones is produced by the adrenal gland?

(A) Thyroxine

(B) Cortisol

(C) Insulin

(D) Melatonin

Q.6 What is the ploidy level of a sporophyte in angiosperms?

(A) n

(B) 2n

(C) 3n

(D) 4n

Q.7 The standard free energy change (ΔG°) of the binding reaction between different sweet molecules and a common sweet taste receptor are given. Which amongst these molecules is the sweetest at the same molar concentration?

(A) Sucrose (- 6.7 kcal mol^{-1})

(B) Saccharin (- 9.7 kcal mol^{-1})

(C) Alitame (- 11.1 kcal mol^{-1})

(D) Neotame (- 12.1 kcal mol^{-1})

Q.8 The correct order of electronegativity of the given elements is

(A) B > C > N > O > F

(B) F > O > N > C > B

(C) F > N > O > C > B

(D) O > F > N > C > B

Q.9 Which of the following terrestrial biomes has the highest animal diversity?

(A) Tropical forest

(B) Savana

(C) Chaparral

(D) Tundra

Q.10 An electric circuit with a resistor of constant resistance ‘R’ is maintained at a constant voltage ‘V’. Based on Ohm’s law, if the current ‘I’ through the circuit is doubled, the power ‘P’ dissipated across the resistor is

(A) P/2

(B) P

(C) 2P

(D) 4P

Section A: Q.11 – Q.30 Carry TWO marks each.

Q.11 Sequence comparison of which of the following genes is used as a measure of evolutionary divergence across bacterial species?

(A) *pbpG*

(B) *slyD*

(C) 16S rRNA

(D) 18S rRNA

Q.12 Which of the following activities is NOT possessed by the human immunodeficiency virus-1 reverse transcriptase?

(A) Synthesis of DNA from RNA

(B) Synthesis of DNA from DNA

(C) Degradation of RNA strand of RNA: DNA hybrid

(D) Synthesis of mRNA from DNA

Q.13 Bacterial cloning vectors and bacterial expression vectors are differentiated by the presence of

(A) antibiotic resistance gene cassette

(B) origin of replication

(C) promoter and ribosome-binding site

(D) unique restriction sites

Q.14 The final stage of peptidoglycan (PG) biosynthesis is marked by PG cross-link formation and remodeling. Which of the following enzymes does NOT take part in these processes?

(A) Transglycosidases

(B) Transpeptidases

(C) Transaminases

(D) DD-carboxypeptidases

Q.15 The first evidence of ‘gene transfer’ was demonstrated in 1928 by

(A) Joshua Lederberg in *Escherichia coli*

(B) Frederick Griffith in *Streptococcus pneumoniae*

(C) Joshua Lederberg in bacteriophages

(D) Alexander Fleming in *Penicillium notetum*

Q.16 Which of the following statements about eukaryotic asymmetric cell division is NOT correct?

(A) Chromosomes are unequally distributed in the daughter cells

(B) Chromosomes are equally distributed in the daughter cells

(C) RNA and proteins are unequally distributed in the daughter cells

(D) Cytoplasmic contents are unequally distributed in the daughter cells

Q.17 Which of the following represents the CORRECT order of events in the eukaryotic cell cycle?

(A) $G1 \rightarrow S \rightarrow G2 \rightarrow M$

(B) $S \rightarrow G1 \rightarrow M \rightarrow G2$

(C) $G1 \rightarrow S \rightarrow M \rightarrow G2$

(D) $S \rightarrow G1 \rightarrow G2 \rightarrow M$

Q.18 The receptors for gamma amino butyric acid (GABA) in humans are

(A) ligand gated chloride ion channels

(B) ligand gated sodium ion channels

(C) ligand gated potassium ion channels

(D) ligand gated calcium ion channels

Q.19 Which of the following cell types is infected by the human immunodeficiency virus-1?

(A) T-helper lymphocytes

(B) T-cytotoxic lymphocytes

(C) Plasma cells

(D) B-lymphocytes

Q.20 The IR stretching frequency of the carbonyl (C=O) group of a typical saturated ketone is 1715 cm^{-1}. The IR stretching frequencies for the carbonyl groups present in three different acetophenone (methyl phenyl ketone) derivatives are given. Match the molecules in Group I with their corresponding frequencies in Group II

Group I		Group II (Frequency of C=O group (cm^{-1})	
P	*p*-amino acetophenone	1	1677
Q	*p*-nitro acetophenone	2	1700
R	*p*-methoxy acetophenone	3	1684

(A) P-1, Q-2, R-3

(B) P-2, Q-3, R-1

(C) P-3, Q-1, R-2

(D) P-3, Q-2, R-1

Q.21 Two charges 10×10^{-8} C and -6×10^{-8} C are located 16 cm apart. The point(s) on the line joining the two charges, where the net electric potential is zero, will be

[Take the potential at infinity to be zero]

(A) 10 cm and 40 cm away from the positive charge on the side of the negative charge

(B) 10 cm and 40 cm away from the negative charge on the side of the positive charge

(C) 10 cm away from the negative charge on the side of the positive charge

(D) 40 cm away from the negative charge on the side of the positive charge

Q.22 Match the pair of orgamisms in Group I with their community interaction pattern in Group II.

Group I		Group II	
P	Cattle egrets – African buffalo	1	Competition
Q	Lynx – Fox	2	Predation
R	Acacia tree – Pugnacious ants	3	Commensalism
S	Leopard – Antelope	4	Mutualism

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

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

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

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

Q.23 Match the animals in Group I with the major form of excreted nitrogen metabolite in Group II

Group I		Group II	
P	Bony fishes	1	Urea
Q	Lions	2	Uric acid
R	Birds	3	Ammonia

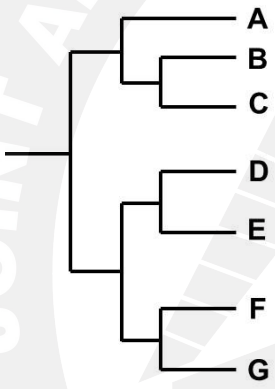
(A) P - 3, Q - 1, R - 2

(B) P - 1, Q - 2, R - 3

(C) P - 2, Q - 3, R - 1

(D) P - 3, Q - 2, R - 1

Q.24 Identify the taxa that constitute a paraphyletic group in the given phylogenetic tree ?



(A) A, B, C

(B) D, E, F

(C) B, C, D

(D) C, D, E

Q.25 Which of the following is the CORRECT combination of a synthetic auxin and a synthetic cytokinin?

(A) 2,4-Dichlorophenoxy acetic acid (2,4-D) and Indole-3-acetic acid (IAA)

(B) 2,4-Dichlorophenoxy acetic acid (2,4-D) and 6-Benzylamino purine (BAP)

(C) 6-Benzylamino purine (BAP) and Zeatin

(D) Indole-3-acetic acid (IAA) and Zeatin

Q.26 Mechanism of antibacterial action of polymyxins relies on the

(A) inhibition of 30S ribosomal subunit

(B) disruption of peptidoglycan synthesis

(C) inhibition of DNA replication of bacteria

(D) disruption of membrane architecture of bacteria

Q.27 The 5′ cap of eukaryotic mRNAs contains

(A) a modified guanine nucleotide

(B) a modified adenine nucleotide

(C) a modified cytosine nucleotide

(D) a modified uracil nucleotide

Q.28 Which one of the following statements is CORRECT about *Agrobacterium tumefaciens*-mediated plant transformation?

(A) The marker gene for the selection of plant transformant is located outside the T-DNA segment of the transformation plasmid

(B) The marker gene for the selection of bacterial transformant is located within the T-DNA segment of the transformation plasmid

(C) Two T-DNA border sequences (left and right) are essential to design a binary vector system

(D) In binary vector system, the *vir* genes and two T-DNA border sequences (left and right) are present in the same transformation plasmid

Q.29 Which of the following conditions is CORRECT for free expansion of an ideal gas under adiabatic condition? (q = heat, ΔT = temperature difference, w = work)

(A) $q = 0, \Delta T < 0, w \neq 0$

(B) $q = 0, \Delta T \neq 0, w = 0$

(C) $q \neq 0, \Delta T = 0, w = 0$

(D) $q = 0, \Delta T = 0, w = 0$

Q.30 Four alkyl halides, MeBr, EtBr, *i*-PrBr and *t*-BuBr, undergo S_N2 reactions in the presence of hydroxide ion to yield the corresponding alcohols and the halide ion. The CORRECT order of the alkyl halides based on the rates of reactions is

(A) MeBr > EtBr > *i*-PrBr > *t*-BuBr

(B) *t*-BuBr > *i*-PrBr > EtBr > MeBr

(C) *i*-PrBr > *t*-BuBr > EtBr > MeBr

(D) EtBr > *i*-PrBr > *t*-BuBr > MeBr

Section B: Q.31 – Q.40 Carry TWO marks each.

Q.31 Which of the following statement(s) is/are CORRECT about *Deinococcus radiodurans*?

(A) It has a cell wall consisting of several layers, including an outer membrane that lacks lipid A

(B) Peptidoglycan in its cell wall has ornithine, in place of diaminopimelic acid, in the N-acetyl muramic acid cross-bridges

(C) It is a Gram-negative organism

(D) It can survive an exposure up to 15000 Gy of ionizing radiation

Q.32 Which of the following statement(s) is/are CORRECT about ‘stringent response’ in bacteria?

(A) It is linked to reduced growth rate

(B) Guanosine tetraphosphate (ppGpp) alone is sufficient to trigger the process

(C) Both guanosine tetraphosphate (ppGpp) and guanosine pentaphosphate (pppGpp) are required to trigger the process

(D) RelA and/or SpoT are/is involved in triggering the process

Q.33 The method(s) used to detect a DNA fragment of 150 base pairs is/are

(A) agarose gel electrophoresis

(B) northern blotting

(C) polyacrylamide gel electrophoresis

(D) western blotting

Q.34 The component(s) of the apoptosome is/are

(A) cytochrome c

(B) procaspase 9

(C) caspase 3

(D) caspase 8

Q.35 Which of the following statement(s) is/are CORRECT for *lac* repressor expressed from the *lacI* gene?

(A) The *lac* repressor is allosterically controlled and it binds to *lac* operator

(B) The gene *lacI* is in the '*cis*' configuration with respect to *lac* operon

(C) The presence of glucose weakens the binding of *lac* repressor to *lac* operator

(D) The *lac* repressor regulates '*in trans*' the expression of a gene cloned under the control of *lac* promoter

Q.36 Which of the following condition(s) lead(s) to reduced affinity of O_2 for human hemoglobin?

(A) Reduction of pH of blood plasma from pH 7.4 to 7.2

(B) Decrease of partial pressure of CO_2 in the lungs from 6 to 2 kPa

(C) Enhancement of intracellular 2, 3-*bis* phosphoglycerate (BPG) level from 5 to 8 mM

(D) Increase in ambient CO level from 1 to 600 ppm

Q.37 Which of the following metabolite(s) accumulate(s) in the blood of a human adult consuming a ketogenic diet?

(A) D-β-hydroxybutyrate

(B) Acetoacetate

(C) Pyruvate

(D) Oxaloacetate

Q.38 In 'Futile Cycle' chemical energy is dissipated as heat due to two opposite biochemical reactions. Which of the following biochemical reaction(s) is/are a part of 'Futile Cycle'?

(A) Glucose ↔ Glucose-6-phosphate

(B) Fructose-6-phosphate ↔ Fructose-1,6-bisphosphate

(C) Glucose-6-phosphate ↔ Fructose-6-phosphate

(D) 1,3-bisphosphoglycerate ↔ 3-phosphoglycerate

Q.39 Which of the following statement(s) is/are CORRECT in the classical 'ABC model' for genetic control of flower development?

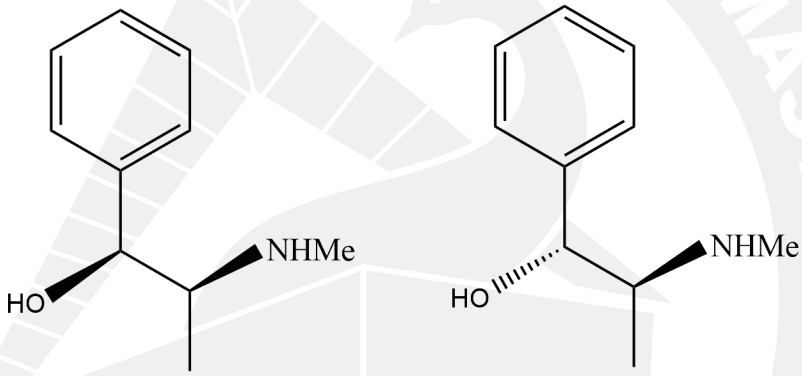
(A) 'Class A' genes solely determine sepal identity

(B) 'Class B' genes solely determine petal identity

(C) 'Class C' genes solely determine stamen identity

(D) 'Class C' genes solely determine carpel identity

Q.40 Which of the following is/are CORRECT for the two molecules shown?



(A) They are stereoisomers

(B) Each of them has two stereogenic centers

(C) They are mirror images of each other

(D) They are diastereoisomers

Section C: Q.41 – Q.50 Carry ONE mark each.

Q.41 Free energy change for transport of an uncharged solute across a membrane against a $1x10^3$ fold concentration gradient at 25 °C is _____kJ mol^{-1}. (rounded off to 2 decimals)

[R = 8.315 J mol^{-1} K^{-1}]

Q.42 A forest has four different tree species (A, B, C and D) and their numbers are:

A = 60; B = 20; C = 10 and D = 10.

The Shannon biodiversity index of the trees in this forest is_____. (rounded off to 2 decimals)

Q.43 In a plant species, the genotype ***DDEE*** is crossed with the genotype ***ddee***; and the F_1 is test crossed. Considering that the two genes are linked and 20 map unit (cM) apart in the chromosome, the percentage (%) of the test cross progeny with the genotype ***ddee*** is _____. (answer in integer)

Q.44 In a farm animal breeding programme, the animal with the dominant ***A*** phenotype, the recessive ***b*** phenotype, the dominant ***D*** phenotype, and the recessive ***e*** phenotype are commercially important. The inheritance of these traits follows Mendelian laws. From the tetra-hybrid cross of two genotypes ***AaBbDdEe*** and ***AaBbDdEe***, the expected frequency of offspring that will show all the above-mentioned desired phenotypes is _____. (rounded off to 3 decimals)

Q.45 The wavelength of a photon emitted during a transition from n = 3 to n = 2 state in the H atom is _____ nm. (answer in integer).

[Rydberg energy constant $R_H = 2.18 \times 10^{-18}$ J; Planck constant $h = 6.626 \times 10^{-34}$ J s, $c = 3 \times 10^8$ m s^{-1}]

Q.46 The limit of the function $\lim_{x \to 2} \left(\frac{2x^2+2x-12}{x^2-4} \right)$ is _____. (rounded off to 1 decimal)

Q.47 A candle is placed 18 cm in front of a concave mirror to generate a real, inverted and doubly magnified image. The radius of curvature of the concave mirror is _____cm. (answer in integer)

Q.48 E^0 value of a Daniell cell $Zn|Zn^{2+}$ (aq)$||Cu^{2+}$ (aq)$|Cu$ is _____V. (rounded off to 2 decimals)

[$E^0_{Zn^{2+}|Zn}$ = - 0.76 V; $E^0_{Cu^{2+}|Cu}$ = + 0.34 V]

Q.49 A population of bacterial cells grows from 10,000 to 100,000,000 cells in 6 hours. The generation time of the bacterial population is _____min. (rounded off to 2 decimals)

Q.50 In a sampling expedition near a peninsula, 180 dolphins from a large population of dolphins were captured and marked by tagging their dorsal fins. The tagged dolphins were then allowed to join back into the population. In a subsequent expedition, 42 dolphins were photographed from same large population. Among these, 7 dolphins contained the tags. Assuming that the population size remains the same and that tags were not lost, the estimated population size of dolphins in the peninsula is _____. (answer in integer)

Section C: Q.51 – Q.60 Carry TWO marks each

Q.51 The area bounded by the curve $y = sinx$ and the x axis between $x = 0$ and $x = 3\pi/2$ is _____ sq. units. (answer in integer)

Q.52 The number of 7 letter words (with or without meaning) starting with the letter B that can be formed using the letters of the word BIOLOGY is_____. (answer in integer)

Q.53 Three particles A, B, C with masses of 100 g, 200 g, and 300 g, respectively, are placed at the vertices of an equilateral triangular structure with a side length of 2 m. A is placed at the (0, 0) position and B is placed at (2, 0) position in a Cartesian coordinate system. Assume that ΔABC lies parallel to the base. The distance between the center of mass and position of the particle A is _____ m. (rounded off to 2 decimals)

Q.54 An insect weighing 5 g takes off vertically for a distance of 100 cm with a speed of 4 m s^{-1} by using its hind legs. Ignoring the resistance due to air, the magnitude of the average net force exerted by the hind legs during the take-off is _____N. (rounded off to 3 decimals)

[g = 9.8 m s^{-2}]

Q.55 A buffer solution is composed of 0.1 M acetic acid and 0.15 M sodium acetate. The change in pH of 1 L buffer solution upon addition of 50 mL of 1.0 M NaOH is _____. (rounded off to 2 decimals)

[K_a of acetic acid = 1.75 × 10^{-5}]

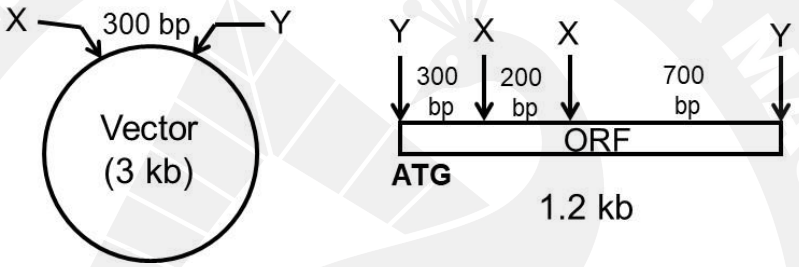
Q.56 In a reaction A + B → C, the initial rate of formation of C at 25 °C was measured for different initial concentrations of A and B as given. The overall order of the reaction with respect to both A and B is _____. (answer in integer)

Experiment	Initial [A] (mol L^{-1})	Initial [B] (mol L^{-1})	Initial rate of formation of C (mol L^{-1} s^{-1})
1	0.4	0.3	0.078
2	0.8	0.3	0.312
3	0.4	0.6	0.156
4	0.8	0.6	0.624

Q.57 A cDNA was synthesized from the mRNA of a eukaryotic gene. After cloning and sequence analysis, the double-stranded cDNA of 614 bp revealed 125 bp 5′-UTR and 120 bp 3′-UTR. The number of amino acids present in the polypeptide encoded by this gene is _____. (answer in integer)

Q.58 A rare genetic disorder resulting from homozygosity for a recessive allele (*r*) occurs in 2 out of every 10,000 individuals in a population. Assuming that (i) the disorder is not lethal, (ii) the disorder does not impact reproductive success, (iii) no new mutations are introduced in the population, and (iv) the population follows Hardy-Weinberg equilibrium, the percentage (%) of the carriers in the population that pass the *r* allele to offspring is_____. (rounded off to 1 decimal)

Q.59 The vector, shown in the figure, has promoter and RBS sequences in the 300 bp region between the restriction sites for enzymes X and Y. There are no other sites for X and Y in the vector. The promoter is directed towards the Y site. The insert containing only an ORF provides 3 fragments after digestion with both enzymes X and Y. The ORF is cloned in the correct orientation in the vector using the single restriction enzyme Y. The size of the largest fragment of the recombinant plasmid expressing the ORF upon digestion with enzyme X is _____ bp. (answer in integer)



Q.60 The length of the edge of a variable cube is increasing at the rate of 25 cm s^{-1}. If the initial length of the edge of the cube is 10 cm, the rate of increase of the surface area of the cube is _____ cm^2 s^{-1}. (answer in integer)