

**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 may be **one or more than one** choice(s) 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 marks 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. The Scribble Pad will be provided for rough work.

**SECTION – A**  
**MULTIPLE CHOICE QUESTIONS (MCQ)**

**Q. 1 – Q.10 carry one mark each.**

Q.1 An acid contains C, H and O atoms. On combustion analysis, 0.454 g of the acid gives 0.418 g of H<sub>2</sub>O and 1.023 g of CO<sub>2</sub>. What is the empirical formula of the acid?

- (A) C<sub>4</sub>H<sub>5</sub>O<sub>2</sub>                      (B) C<sub>3</sub>H<sub>6</sub>O                      (C) CH<sub>2</sub>O                      (D) C<sub>5</sub>H<sub>8</sub>O

Q.2 Ethylbutyrate is responsible for the odor of pineapple. Which one of the following is the structure of ethyl butyrate?



Q.3 If the blood groups of mother and father are AB and O, respectively, what are the blood groups possible for their child?

- (A) AB or A                      (B) AB                      (C) A or B                      (D) AB, A, B or O

Q.4 Which one of the following features distinguishes between gymnosperms and angiosperms?

- (A) Seed formation                      (B) Vascular tissues  
(C) Seed cover                      (D) Gamete production

Q.5 Ecosystem ecology is the study of

- (A) An organism's behavior towards environmental challenges  
(B) Factors that affect the interactions of individuals in a population  
(C) Interactions among biotic and abiotic components  
(D) Factors that affect the interactions among communities in an ecosystem

Q.6 Bacterial strains that do not grow in the absence of a specific nutrient are called

- (A) Heterotrophs                      (B) Chemotrophs                      (C) Autotrophs                      (D) Auxotrophs

Q.7 The type of immunological protection provided by plasma therapy is

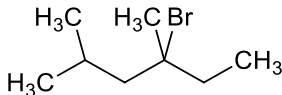
- (A) Natural active                      (B) Natural passive  
(C) Artificial active                      (D) Artificial passive

- Q.8 Which one of the following components of bacterial cell acts as endotoxin?
- (A) Peptidoglycan of Gram-positive bacteria (B) Lipopolysaccharide  
(C) Porins (D) Peptidoglycan of Gram-negative bacteria
- Q.9 The moment of force in terms of fundamental dimensions is
- (A)  $MLT^{-1}$  (B)  $MLT^{-2}$  (C)  $ML^{-1}T^{-1}$  (D)  $ML^2T^{-2}$
- Q.10 Let  $A = \begin{pmatrix} 2 & 1 \\ 1 & 1 \end{pmatrix}$  and  $B = \begin{pmatrix} 2 & -5 \\ 0 & 1 \end{pmatrix}$ . If  $AX + 3B = 0$ , then the determinant of  $X$  is
- (A)  $-18$  (B)  $-6$  (C)  $6$  (D)  $18$

**Q. 11 – Q. 30 carry two marks each.**

- Q.11 In a genetic cross between plants bearing violet flowers and green seeds ( $VVGG$ ), and white flower and yellow seeds ( $vvgg$ ), the following phenotypic distribution was obtained in the  $F_2$  progeny (assume both parents to be pure breeding for both the traits, and self-cross at  $F_1$  generation):
- 2340 plants with violet flowers and green seeds
  - 47 plants with violet flowers and yellow seeds
  - 43 plants with white flowers and green seeds
  - 770 plants with white flowers and yellow seeds

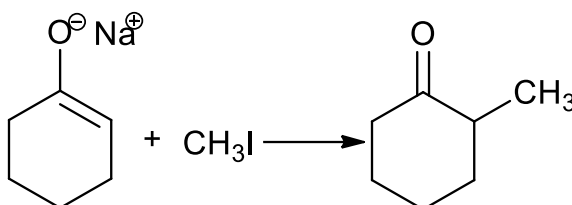
Which one of the following interpretations explains the above phenotypic distribution?

- (A) Same genes control both flower and seed colors  
(B) Genes for flower and seed colors are genetically interacting  
(C) Genes for flower and seed colors are present on the same chromosome  
(D) Flower color in this plant species is a polygenic trait
- Q.12 IUPAC name of the following molecule is
- 
- (A) 3-Bromo-3,5-dimethyl hexane  
(B) 4-Bromo-2,4-dimethyl hexane  
(C) 3-Bromo-2-isobutyl butane  
(D) 4-Bromo-2-methyl-4-ethyl pentane

Q.13 Which one of the following features/properties does glucose acquire through intramolecular hemiacetal formation?

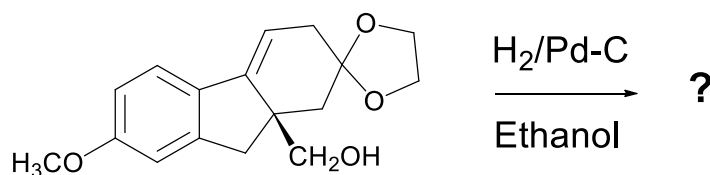
- (A) Ability to function as a reducing agent
- (B) An additional chiral carbon
- (C) Ability to form anhydride linkage with non-carbohydrate moieties such as the inorganic phosphate
- (D) Ability to form epimers

Q.14 The following methylation is carried out in various solvents such as benzene, tetrahydrofuran (THF), dimethoxyethane (DME), dimethyl sulfoxide (DMSO) and N,N-dimethylformamide (DMF). Which one of the following is TRUE for the effect of solvent on the reaction rate?

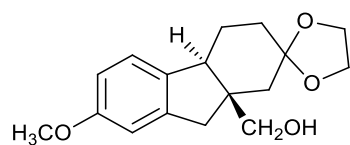


- (A) DMSO > DMF > DME > THF > Benzene
- (B) Benzene > THF > DME > DMF > DMSO
- (C) DME > DMSO > DMF > THF > Benzene
- (D) THF > Benzene > DME > DMSO > DMF

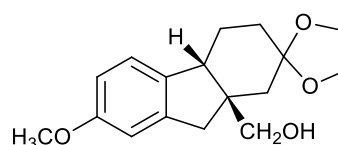
Q.15 Which one of the following is the major product of the hydrogenation reaction given below?



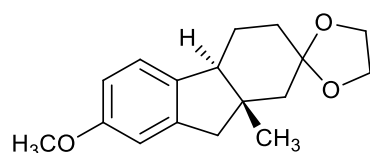
(A)



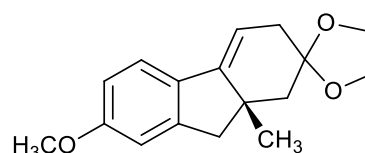
(B)



(C)

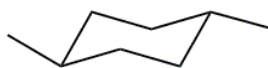


(D)

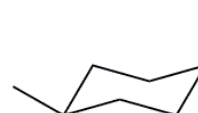


Q.16 Which one of the following isomers is thermodynamically most stable?

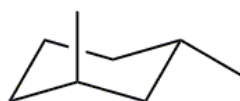
(A)



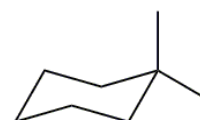
(B)



(C)



(D)



Q.17 What is the significance of the isomerization of glucose 6-phosphate to fructose 6-phosphate for the progression of glycolysis?

(A) As functional groups, ketones are more reactive than aldehydes

(B) Cleavage of glucose 1,6-bisphosphate will not yield dihydroxy acetone phosphate and glyceraldehyde 3-phosphate

(C) The carbonyl group at carbon-2 (C-2) in fructose facilitates the cleavage of the bond between C-3 and C-4

(D) Phosphorylation of glucose 6-phosphate to glucose 1,6-bisphosphate is irreversible

Q.18 What is the role of bile salts in the mammalian digestive system?

(A) Bile salts convert pepsinogen to pepsin, and thus facilitate protein digestion

(B) Bile salts emulsify fat, and thus aid in fat digestion

(C) Bile salts are excretory products produced by the liver, and do not participate in digestion

(D) Bile salts facilitate digestion of all types of macromolecules in the small intestine

Q.19 Presence of which one of the following in the urine indicates pregnancy in human?

(A) Progesterone

(B) Follicle-stimulating hormone and luteinizing hormone

(C) Estrogen

(D) Human chorionic gonadotropin

Q.20 Which one of the following processes emerged earliest during the course of evolution?

(A) Antigen presentation

(B) Antibody production

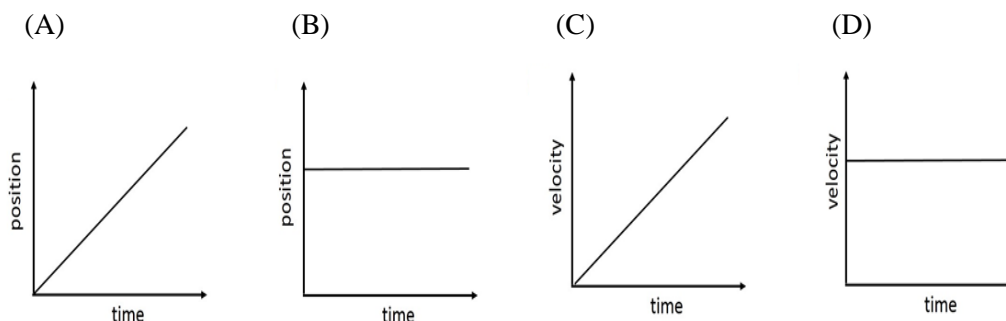
(C) Phagocytosis

(D) Thymic education

Q.21 Which one of the following microscopic techniques provides a 3-dimensional perspective of live, unstained and transparent specimens obtained from the wild?

- (A) Confocal microscopy (B) Fluorescence microscopy  
(C) Phase contrast microscopy (D) Differential interference contrast (Nomarski) microscopy

Q.22 Which one of the following represents the motion of an object with a positive acceleration?



Q.23 A stationary enemy ship is docked in the sea at a distance of 1.0 km from the coastline. A gun located at the sea level on the coastline can fire projectiles at a velocity of 120 m/s. What is the angle (in degrees) above the horizontal at which the gun must fire to hit the ship? [ $g = 9.8 \text{ m/s}^2$ ]

- (A) 21.4 (B) 42.9 (C) 23.6 (D) 47.1

Q.24 If  $x + \frac{1}{x} = 1$ , then the value of  $x^6 + \frac{1}{x^6}$  is

- (A) -2 (B) -1 (C) 1 (D) 2

Q.25

The value of the integral  $\int_0^4 (x - f(x)) dx$ , where  $f(x) = \begin{cases} 0, & 0 \leq x < 1 \\ 1, & 1 \leq x < 2 \\ 2, & 2 \leq x < 3 \\ 3, & 3 \leq x < 4 \\ 4, & 4 \leq x < 5 \end{cases}$  is

- (A) 2 (B) 1 (C) -1 (D) -2

Q.26 In plants, the ovules are attached to the ovary by

- (A) Placenta (B) Synergids (C) Embryo sac (D) Tube cells

Q.27 The lack of linear correlation between the genome sizes and genetic complexities among various species is known as

- (A) C-value paradox (B) Genetic diversity (C) G-value paradox (D) Central dogma

Q.28 Match the cell junctions listed in **Group A** with their correct functions listed in **Group B**:

Group A	Group B
(I). Adherens junction	(P). Joins actin bundles in neighboring cells
(II). Desmosome	(Q). Joins intermediate filaments in neighboring cells
(III). Tight junction	(R). Seals neighboring cells
(IV). Gap junction	(S). Allows diffusion of molecules between adjacent cells

(A) I-S; II-P; III-Q; IV-R

(B) I-Q; II-R; III-P; IV-S

(C) I-Q; II-R; III-S; IV-P

(D) I-P; II-Q; III-R; IV-S

Q.29 In mammals, females have two X chromosomes and males have one X chromosome. Equal expression of X-chromosome genes in both sexes is ensured by

(A) Dosage compensation

(B) Histone code

(C) RNA silencing

(D) Heterochromatin formation

Q.30 The difference between mitosis and meiosis I is

(A) Sister chromatids separate in mitosis, whereas homologous chromosomes separate in meiosis I

(B) The nuclear membrane is absent during mitotic metaphase, but not in meiotic metaphase

(C) The DNA is double helical in meiosis I but not in mitosis

(D) Unlike in mitotic metaphase, chromosomes do not align at the equatorial plate in meiosis I

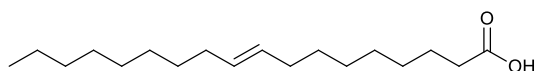
**SECTION - B****MULTIPLE SELECT QUESTIONS (MSQ)**

**Q. 31 – Q. 40 carry two marks each.**

Q.31 Infrared (IR) spectroscopy is used for determining certain aspects of the structure of organic compounds. Which of the following statement(s) is/are FALSE?

- (A) IR radiation induces electronic transitions
- (B) IR peak intensities are related to molecular mass
- (C) Most organic functional groups absorb in a characteristic region of the IR spectrum
- (D) Each element absorbs at a characteristic wavelength

Q.32 Oleic acid, shown below, is



- (A) A saturated fatty acid
- (B) An unsaturated fatty acid
- (C) Insoluble in water
- (D) Soluble in acetone

Q.33 Cyclic AMP (cAMP) acts as a second messenger for which of the following primary signaling molecule(s)?

- (A) Retinoic acid
- (B) Prostaglandins
- (C) Cortisol
- (D) Epinephrine

Q.34 Which of the following is/are TRUE about the electron carrier, ubiquinone (coenzyme Q)?

- (A) Its ability to accept two electrons, one at a time, enables ubiquinone to function at the junction between a 2-electron donor and a 1-electron acceptor
- (B) Being small and hydrophobic, ubiquinone readily shuttles between protein-based electron transfer complexes within the membrane
- (C) Its hydrophilic nature and high affinity for protons enable ubiquinone to transport protons readily within the intermembrane space of mitochondria.
- (D) Its ability to interact with Heme C of cytochromes enables electron transport in the mitochondrial membrane



- Q.35 Which of the following is/are common to both prokaryotic and eukaryotic gene expression?
- (A) Coupled transcription and translation      (B) Post-translational modification  
(C) Genetic code      (D) Presence of the sequence TATA in the promoter
- Q.36 Which of the following molecular genetic technique(s) is/are used in forensic science?
- (A) Coimmunoprecipitation  
(B) DNA fingerprinting  
(C) Restriction fragment length polymorphism  
(D) Electrophoretic mobility shift assay
- Q.37 Which of the following is/are involved in the initiation of DNA replication?
- (A) RhoA      (B) oriC  
(C) Sigma factor      (D) DnaA
- Q.38 Which of the following pairs is/are analogous structures?
- (A) Human hands and bat wings      (B) Butterfly wings and bat wings  
(C) Bat wings and bird wings      (D) Dolphin flippers and fish fins
- Q.39 A charged particle accelerated by a potential  $V$  moves in a circular path with a velocity  $v$  in a uniform magnetic field  $B$  that is perpendicular to the motion. Which of the following is/are correct if the value of  $V$  is increased?
- (A) Kinetic energy of the particle increases  
(B) Radius of the circular path increases  
(C) Time period of the motion increases  
(D) Work done by the magnetic field increases
- Q.40 A function  $f: D \rightarrow \mathbb{R}$  is defined as  $f(x) = \frac{x^2+1}{x^2+x+1}$ , where  $D \subseteq \mathbb{R}$  is the domain. The domain(s) on which the function  $f(x)$  is one to one is/are
- (A) Natural numbers      (B) Integers      (C) Rational numbers      (D) Irrational numbers

## SECTION – C

## NUMERICAL ANSWER TYPE (NAT)

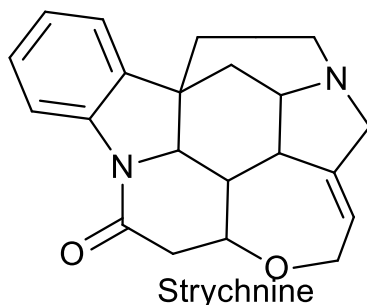
**Q. 41 – Q. 50 carry one mark each.**

- Q.41 1.45 g of sucrose ( $C_{12}H_{22}O_{11}$ ) is dissolved in 30.0 ml of water. Molality (rounded off to 3 decimals) of the resulting solution is \_\_\_\_\_ m.
- Q.42 For a gene present on human chromosome 4, the maximum number of alleles that may be detected by sequencing the genome of 5 males and 10 females is \_\_\_\_\_.
- Q.43 The amount of hydrogen required to reduce 30 g of 2-butene is \_\_\_\_\_ g (rounded off to 2 decimals).
- Q.44 The molar concentration of water in pure water is \_\_\_\_\_ M (rounded off to 1 decimal).
- Q.45 The number of triplet codon(s) for methionine is \_\_\_\_\_.
- Q.46 The number of peptide bonds in a 20-residue linear peptide is \_\_\_\_\_.
- Q.47 When the molecular weight of human immunoglobulin light chain is 24 kDa, the total molecular weight of human IgG is \_\_\_\_\_ kDa.
- Q.48 The maximum number of genotypes possible for gametes formed from a diploid cell of the genotype  $AaBbCcDd$  is \_\_\_\_\_.
- Q.49 The de Broglie wavelength of a proton moving at a speed of 1.0 m/s is \_\_\_\_\_ Å.  
[Planck's constant =  $6.626 \times 10^{-34}$  m<sup>2</sup>kg/s;  $m_p = 1.67 \times 10^{-27}$  kg]
- Q.50 The distance between the parallel lines  $2x + 5y = 7$  and  $2x + 5y = 15$  is \_\_\_\_\_ (rounded off to 2 decimals).

**Q. 51 – Q. 60 carry two marks each.**

Q.51 At 25°C and pH 7.0, the concentrations of glucose 1-phosphate and glucose 6-phosphate are 2.0 mM and 38 mM, respectively at equilibrium. The standard free energy change for the conversion of glucose 1-phosphate to glucose 6-phosphate is \_\_\_\_ J/mol. [ $R = 8.315 \text{ J mol}^{-1} \text{ K}^{-1}$ ]

Q.52



The number of chiral carbons in strychnine is \_\_\_\_\_.

Q.53 The number of polypeptide chains in a core nucleosome is \_\_\_\_\_.

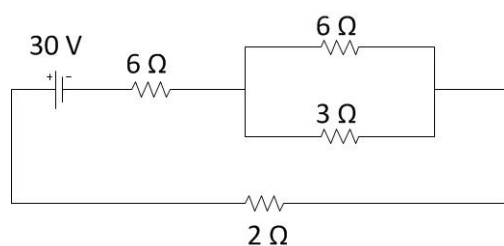
Q.54 While performing a PCR, the student forgot to add one of the two primers. The number of molecules of single-stranded DNA produced after 25 PCR cycles is \_\_\_\_\_

Q.55 A double helical DNA molecule is composed of 32 mol % of adenosine. The mol % of cytosine in this DNA molecule is \_\_\_\_\_.

Q.56 In a compound microscope, the magnification power of the objective lens is 100x, and that of the eye piece (ocular lens) is 10x. The magnification power of the microscope is \_\_\_\_\_ x.

Q.57 In a population at Hardy-Weinberg equilibrium, for *gene-X* only two alleles, namely *A* and *a*, are found. If frequency of allele *A* is 0.2 and the frequency of allele *a* is 0.8, the frequency of the heterozygote genotype *Aa* in that population will be \_\_\_\_\_ (correct to 2 decimal places).

Q.58 In the circuit shown below, the power dissipated across the  $3\Omega$  resistor is \_\_\_\_\_ W.



Q.59 The equation  $\sin \frac{\theta}{2} \left( \sin \frac{\theta}{2} + \cos \frac{\theta}{2} \right) = \beta$  has a solution, where  $\beta$  is a natural number. Then  $\beta$  is \_\_\_\_\_.

Q.60 The velocity of blood in a blood vessel of 2.0 cm radius is 30 cm/s. When the blood vessel bifurcates into 2 smaller vessels of radius 1.0 cm each, the velocity of blood in each of the smaller vessels is \_\_\_\_\_ cm/s. Assume that the vessel walls are rigid, and blood is incompressible.

**END OF THE QUESTION PAPER**