PAPER : IIT-JAM 2019

BIOTECHNOLOGY-BT

INSTRUCTIONS:

(*i*) This test paper has a total of 60 questions carrying 100 marks. The entire question paper is divided into three **sections**, **A, B** and **C**. All sections are compulsory. Questions in each section are of different types.

(*ii*) **Section-A** contains **Multiple Choice Questions (MCQ)**. Each MCQ type question has four choices out of which only one choice is the correct answer. This section has 30 Questions 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.

(*iii*) **Section-B** contains **Multiple Select Questions (MSQ)**. Each MSQ type question is similar to MCQ but 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 choices only and no wrong choices. This section has 10 Questions and carry **2 marks** each with a total of 20 marks.

(*iv*) **Section-C** contains **Numerical Answer Type (NAT)** questions. For these NAT type questions, the answer is a real number which needs to be entered using the virtual numerical keypad on the monitor. No choices will be shown for these type of questions. This section has 20 Questions and carry a total of 30 marks. Q.1 – Q.10 carry 1 mark each and Questions Q.11 – Q.20 carry **2 marks** each.

(*v*) In all questions, question 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.

SECTION-A

[Multiple Choice Questions (MCQ)]

1. At what pH does poly-Glu in an aqueous solution form α-helical structure ?

   (a) 3 (b) 7 (c) 9 (d) 12

2. The technique that involves impacting samples with electrons is ____.

   (a) NMR spectroscopy (b) ESI mass spectrometry

   (c) IR spectroscopy (d) UV-vis spectroscopy

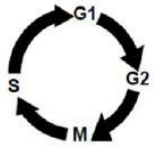
3. Let $U = \{1, 2, 3, 4, 5\}$. A subset S is chosen uniformly at random from the non-empty subsets of U. What is the probability that S does **NOT** have two consecutive elements ?

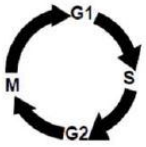
   (a) 9/31 (b) 10/31 (c) 11/31 (d) 12/31

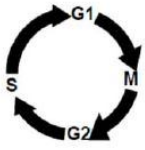
4. Which one of the points $P = \left(\frac{3}{2}, \frac{1}{2}\right), Q = \left(\frac{1}{2}, \frac{3}{2}\right), R = \left(\frac{3}{2}, \frac{11}{2}\right)$ and $S = \left(\frac{11}{2}, \frac{3}{2}\right)$ lies ABOVE the parabola $y = 2x^2$ and INSIDE the circle $x^2 + y^2 = 4$?

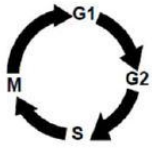
   (a) P (b) Q (c) R (d) S

5. Which of the following figures represents the correct sequence of phases in adult eukaryotic cell cycle ?

   (a) 

   (b) 

   (c) 

   (d) 

6. The glycosidic linkages in cellulose and amylose are _____, respectively.

   (a) α 1-4 and β 1-4 (b) β 1-4 and α 1-4 (c) β 1-4 and α 1-6 (d) α 1-4 and α 1-2

7. Match the entries in Group I with the entries in Group II

Group I	Group II
P. Nylon	(i) Isoprene
Q. Natural rubber	(ii) Hexose
R. Starch	(iii) Amino acid
S. Myoglobin	(iv) Adipic acid

(a) P-iv, Q-i, R-ii, S-iii (b) P-iv, Q-i, R-iii, S-ii
(c) P-iv, Q-iii, R-ii, S-i (d) P-ii, Q-iv, R-i, S-iii

8. A mutation in the operator locus of *lac* operon that confers constitutive expression of β -galactosidase is _____.
(a) *cis* dominant (b) trans dominant (c) co-dominant (d) dominant negative

9. The orbital angular momentum of hydrogen atom in the ground state is _____.
(a) 0 (b) $\frac{h}{2\pi}$ (c) $\frac{h}{2}$ (d) h

10. The dimensions of coefficient of viscosity are _____.
(a) $ML^{-1}T^{-1}$ (b) $ML^{-1}T^{-2}$ (c) $ML^{-2}T^{-2}$ (d) $ML^{-2}T^{-1}$

11. A particle starting from rest is subjected to a constant force. The plot of distance traveled along the direction of the force as a function of time is a/an_____.
(a) straight line (b) circle (c) parabola (d) ellipse

12. According to the kinetic theory of gases, the average energy of a diatomic molecule in an ideal gas depends on _____.
(a) mass of each atom and the temperature
(b) mass of each atom and the bond length
(c) mass of each atom, bond length, and temperature
(d) temperature only

13. Which one of the following modifications occurs both on DNA and protein ?
(a) ADP-ribosylation (b) Methylation (c) Sumoylation (d) Ubiquitination

14. In a simple microscope, _____.
(a) a lens with negative power is used
(b) the focal length of the lens is less than the least distance for clear vision
(c) the focal length of the lens is greater than the least distance for clear vision
(d) magnification depends only on the focal length of the lens

15. Simplify $\frac{\sin A}{1+\cos A}+\frac{1+\cos A}{\sin A}$.
(a) 2 sec A (b) 2 cosec A (c) sec A (d) cosec A

16. The evolution of eyes in octopus and in human is an example of _____.
(a) divergent evolution (b) convergent evolution
(c) adaptive radiation (d) genetic drift

17. Indole acetic acid (IAA) is involved in _____.
(a) gravitropism (b) flowering (c) ripening (d) senescence

18. Let $a=\frac{\sqrt{5}+1}{2}$ and $b=\frac{\sqrt{5}-1}{2}$. Then, $\lim_{n\to\infty}\frac{a^n+b^n}{a^n-b^n}$
(a) is 1 (b) is 1/2 (c) is 0 (d) does not exist

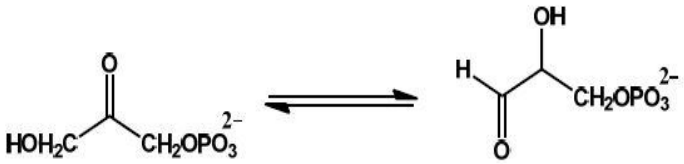
19. Among the following species, the metal center that has the highest number of unpaired electrons is

(a) VCl_4 (b) $Ni(CO)_4$ (c) $[AuCl_4]^-$ (d) $[CdBr_4]^{2-}$

20. Which one of the following statements is a correct description of modes of action of taxol and colchicine ?

(a) Taxol causes DNA damage and colchicine prevents microtubule formation
(b) Taxol stabilizes microtubules and colchicine inhibits protein synthesis
(c) Taxol destabilizes microtubules and colchicine promotes microtubule formation
(d) Taxol stabilizes microtubules and colchicine prevents microtubule formation

21. The following reaction is an example of _____.



(a) enolization (b) racemization (c) isomerization (d) epimerization

22. Which one of the following statements is INCORRECT with respect to bacterial conjugation ?

(a) It facilitates transfer of genetic material (b) It requires flagellum
(c) It can spread antibiotic resistance (d) It can transfer virulence factors

23. The free energy required to synthesize a mixed anhydride bond of 1, 3-bisphosphoglycerate is generated by the oxidation of _____.

(a) an aldehyde to acid (b) an alcohol to acid
(c) an alcohol to aldehyde (d) NADH to NAD^+

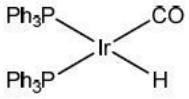
24. Which one of the following remains unchanged when light waves enter water from air ?

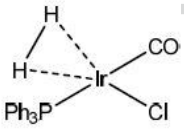
(a) Wavelength (b) Wavenumber (c) Frequency (d) Intensity

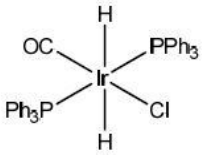
25. Solutions of the following peptides are prepared separately at a concentration of 1mM. Among these four, which one has the highest A_{280}?

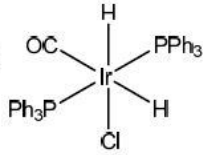
(a) Ser-Val-Trp-Asp-Phe-Gly-Tyr-Trp-Ala (b) Gln-Leu-Glu-Phe-Thr-Leu-Asp-Gly-Tyr
(c) Met-Gly-Val-Ileu-Asp-Ser-Ala-Trp-His (d) His-Pro-Gly-Asp-Val-Ileu-Phe-Met-Leu

26. H_2 reacts with trans-$(Ph_3P)_2Ir(CO)Cl$ to primarily produce ____.

(a) 

(b) 

(c) 

(d) 

27. Which one of the following parameters changes upon doubling the enzyme concentration?

(a) K_M (b) V_{max} (c) K_{cat} (d) K_{eq}

28. In how many ways can one write the elements 1, 2, 3, 4 in a sequence x_1, x_2, x_3, x_4 with $x_i \neq i \forall i$?

(a) 9 (b) 10 (c) 11 (d) 12

29. Match the entries in Group I with entries in Group II

Group I	Group II
P. Bacteria	(i) Malaria
Q. Virus	(ii) Tuberculosis
R. Protozoa	(iii) Influenza
S. Autoantibodies	(iv) Myasthenia gravis

(a) P-ii, Q-i, R-iii, S-iv (b) P-ii, Q-iii, R-i, S-iv
(c) P-iv, Q-iii, R-i, S-ii (d) P-i, Q-iv, R-ii, S-iii

30. pK_a increases in the order _____.

(a) $HN_3 > NH_3OH^+ > N_2H_5^+ > NH_3$ (b) $NH_3OH^+ > N_2H_5^+ > HN_3 > NH_3$

(c) $NH_3 > NH_3OH^+ > N_2H_5^+ > HN_3$ (d) $HN_3 > N_2H_5^+ > NH_3 > NH_3OH^+$

SECTION-B

[Multiple Selective Questions (MSQ)]

1. The advantage(s) of storing chemical energy in the form of starch and not as free glucose is/are that it _____.
   (a) minimizes diffusion
   (b) enables compact storage
   (c) reduces osmotic pressure
   (d) protects against chemical reactivity of aldehyde groups

2. BF_3 reacts readily with _____.
   (a) C_5H_5N (b) $SnCl_2$ (c) SO_3 (d) $(C_5H_5N) - SnCl_2$

3. Let $U = \{1, 2, ..., 15\}$. Let $P \subseteq U$ consists of all numbers, $Q \subseteq U$ consists of all even numbers and $R \subseteq U$ consist of all multiples of 3. Let $T = P - Q$. Then, which of the following is/are CORRECT?
   (a) $|T| = 5$ and $|T \cup R| = 9$ (b) $|T| = 6$ and $|T \cup R| = 9$
   (c) $|T| = 5$ and $|T \cap R| = 1$ (d) $|T| = 6$ and $|T \cap R| = 1$

4. Electromagnetic waves ____.
   (a) carry energy (b) carry momentum
   (c) are transverse in nature while travelling in vacuum (d) do not need a material medium to travel

5. Which of the following statement(s) is/are true?
   (a) In intrinsic semiconductors, the number of electrons is equal to the number of holes at any temperature
   (b) An intrinsic semiconductor changes to an *n*-type semiconductor upon addition of a trivalent element
   (c) The shape of the I-V characteristics of a *p-n* diode is a straight line
   (d) In the reverse bias condition, the current in a *p-n* diode is due to the minority carriers

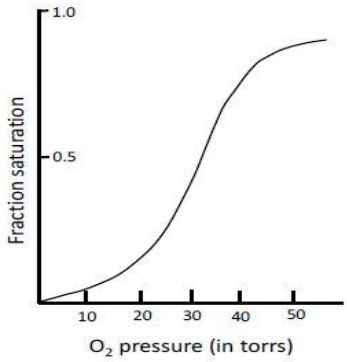
6. The reaction of (R)-2-bromobutane with CN^- proceeds by ____.
   (a) retention of configuration (b) inversion of configuration
   (c) formation of $CH_2 = CH(CH_2CH_3)$ (d) formation of (S)-2-methylbutanenitrile

7. Pick the correct statement(s) with respect of the inter-conversion of the topoisomers of a circularly closed double stranded DNA.
   (a) Only one strand needs to be cut (b) Both strands have to be cut
   (c) No strand needs to be cut (d) ATP is required for inter-conversion

8. Let $f(x) = (x-1)(x-2)(x-3)(x-4)$ and let $\alpha = f\left(\frac{3}{2}\right), \beta = f\left(\frac{5}{2}\right)$ and $\gamma = f\left(\frac{7}{2}\right)$. Which of the following is/are CORRECT?
   (a) α and β have the same sign (b) α and γ have the same sign
   (c) β and γ have the same sign (d) $\alpha\ \beta$ and $\beta\ \gamma$ have the same sign

9. Which of the following cell types can develop from myeloid lineage ?
   (a) Macrophages (b) T lymphocytes (c) B lymphocytes (d) Erythrocytes

10. The characteristic oxygen binding profile of hemoglobin shown below arises due to the ____.



(a) quaternary structure
(b) Subunit dissociation
(c) cooperativity
(d) conformational change

SECTION-C

[Numerical Answer Type (NAT)]

1. The total number of multiplet peaks in the ^1H NMR spectrum of 1, 3, 5-tri-isopropylbenzene in $CDCl_3$ is ____.
2. Proinsulin is an 84 residue polypeptide with six cysteines. How many different disulfide combinations are possible ?
3. Heterozygous female fruit flies with gray body and purple eyes were mated with homozygous males with black body and red eyes. The number of offspring obtained and their phenotypes are shown below :

Number of offspring	Phenotype
300	Gray body – purple eyes
347	Black body – red eyes
61	Gray body – red eyes
55	Black body – purple eyes

Calculate the recombination frequency.

4. The refractive index of a liquid relative to air is 1.5. Calculate the ratio of the real depth to the apparent depth when the liquid is taken in a beaker.
5. C_3 plants utilize 18 molecules of ATP to synthesize one molecule of glucose from CO_2. How many molecules of ATP equivalents are used by C_4 plants to synthesize one molecule of glucose from CO_2 ?
6. A metallic wire of electrical resistance $40\,\Omega$ is bent in the form of a square loop. The resistance between any two diagonally opposite comers is ____ Ω.
7. Let XYZ be an equilateral and let P, Q, R be the mid point of YZ, XZ and XY, respectively.

   Let $r = \dfrac{Area(\Delta PQR)}{Area(\Delta XYZ)}$.

   The value of r is ____.
8. Let N be the set of natural number and $f : N \to N$ be defined by

$$f(x) = \begin{cases} x/2, & x \text{ is even} \\ 3x+1, & x \text{ is odd} \end{cases}$$

Let $f^n(x)$ denote the n-fold composition of $f(x)$. What is the smallest integer n such that $f^n(13) = 1$?

9. The total number of lone pairs of electrons in NO_2F is ____.

10. A 0.1% (w/v) solution of a protein absorbs 20% of the incident light. What fraction of light is transmitted if the concentration is increased to 0.4%? [Correct to two decimal places]

11. The total number of DNA molecules present after 5 cycles of polymerase chain reaction (PCR) starting with 3 molecules of template DNA is ____.

12. An infinitely long solenoid of radius r and number of turns per unit length n carries a steady current I. The ratio of the magnetic fields at a point on the axis of the solenoid to a point $r/2$ from the axis is ____.

13. In a bacterium, a mutation resulted in an increase of K_s (substrate-specific constant) for ammonium from 50 μM to 5000 μM without affecting μ_{max}. The specific growth rate (μ) of the mutant growing on 0.5 mM ammonium in the medium decreases by a factor of ____.

14. The value of $\int_0^{\frac{\pi}{2}} x \sin x dx$ is ____.

15. The standard emf of a cell (in V) involving the reaction, $2Ag^+(aq.) \rightarrow Ag(s) + Ag^{2+}(aq.)$ at 298 K is ____. [Correct to two decimal places]

[Given : $Ag^+(aq.) + e \rightarrow Ag(s); E^o = 0.62V$ and $Ag^{2+}(aq.) + e \rightarrow Ag^+(aq.); E^o = 0.12V$]

16. Phosphoglucoisomerase catalyzes the following reaction:

$\text{Glu} - 6 - P \rightleftarrows \text{Fru} - 6 - P$

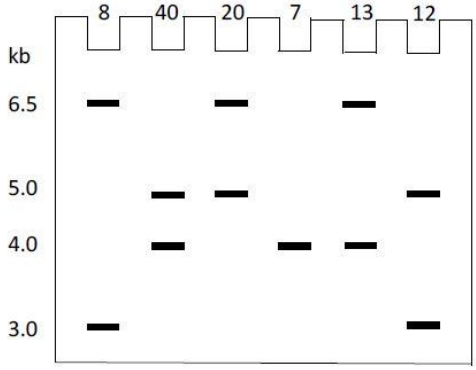
If 0.05% of the original concentration of Glu-6-P remains at equilibrium, then equilibrium constant of this reaction is ____.

17. Let $\vec{a} = 4\hat{i} - 2\hat{j} + 6\hat{k}$ and $\vec{b} = 7\hat{i} + \hat{j} - 12\hat{k}$. If $\vec{a} \times \vec{b} = \alpha\hat{i} + \beta\hat{j} + \gamma\hat{k}$, then the value of $\alpha + \beta + \gamma$ equals ____.

18. The concentration of NaCl (in mM) formed at the stoichiometric equivalence point when 10 mL of 0.1 M HCl solution is titrated with 0.2 m NaOH solution is ____. (as an integer)

19. Two identical, infinite conducting plates are kept parallel to each other and are separated by a distance d. The uniform charge densities on the plates are $+\sigma$ and $-\sigma$. The electric field at a point between the two plates $n\left(\frac{\sigma}{\varepsilon_0}\right)$, where n is ____.

20. A schematic representation of restriction fragment length polymorphism (RFLP) analysis of a sample population is shown below. The number of people exhibiting a given pattern is indicated above the lanes.



Calculate the frequency of 6.5 kb allele. [Correct to two decimal places]