

PAPER : IIT-JAM 2015
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.
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SECTION – A

MULTIPLE CHOICE QUESTIONS (MCQ)

Q.1 – Q.10 carry one mark each.

1. Which one of the following most accurately describes the process of natural selection?
 - (a) Selection of one species over a competing species
 - (b) Selection of individuals that successfully defend themselves against enemies
 - (c) Selection of individuals that produce more than the average number of offspring
 - (d) Selection of individuals that are more attractive to the opposite sex

 2. Identify the statement that is **TRUE** of operons
 - (a) Fine regulation of the expression of individual genes are made possible by operons
 - (b) Only genes involved in carbohydrate metabolism are present in operons
 - (c) Feedback inhibition of the biosynthesis of multiple enzyme by a single small molecule is made possible by operons
 - (d) In the case of inducible operons, the inducer binds to the operator
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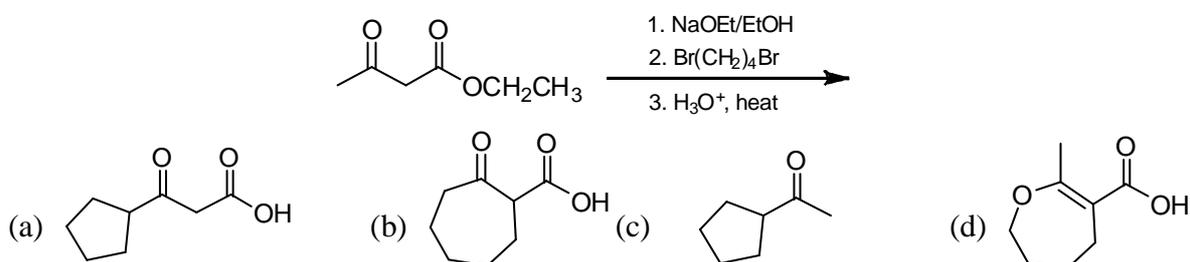


3. Signaling pathways usually comprise of several intermediate steps that are arranged in the form of a cascade. What is the primary outcome of such an arrangement?
- (a) Specificity of signal transduction (b) Specificity of the cellular response
(c) Amplification of the cellular response (d) Fine-tuning of the cellular response
4. Which among the following contain(s) oxygen-rich blood in the human vascular system?
- I. Right ventricle
II. Aorta
III. Pulmonary vein
- (a) I only (b) I and II only
(c) I, II and III (d) II and III only
5. Choose the option that lists the correct sequence of steps involved in gene therapy
- P. Injection of expression vector into patient
Q. Wild-type gene is inserted into expression vector
R. Wild-type gene is isolated and cloned
S. Wild-type gene is transcribed and translated in the patient
- (a) Q, S, P, R (b) Q, P, R, S (c) R, P, Q, S (d) R, Q, P, S
6. Cephalin, a biological surfactant, is
- (a) choline phosphoglyceride (b) ethanolamine phosphoglyceride
(c) glycosphingolipid (d) sphingolipid
7. The major product(s) produced by gas phase UV irradiation of 2-pentanone is (are)
- (a) acetone and ethene (b) acetic acid and propionic acid
(c) 2-pentanol (d) cyclopentane
8. If a projectile lifts off from the surface of the Earth with a speed of 11.2 km.s^{-1} , then it can escape from the Earth's gravitational field completely. This is called the escape velocity. If the radius of the Earth were 2 times larger and the mass 8 times larger, then the escape velocity (in km.s^{-1}) would be
- (a) 5.6 (b) 11.2 (c) 22.4 (d) 44.8
9. The speed of an electron (v), in the lowest energy orbit in the Bohr model of the Hydrogen atom divided by the speed of light in vacuum (c), is given by (where m is the mass of the electron, M is the mass of proton, ϵ_0 is the permittivity of free space, a_0 is the Bohr radius)
- (a) $\frac{v}{c} = \frac{1}{4\pi\epsilon_0} \frac{e^2}{\hbar c}$ (b) $\frac{v}{c} = \frac{e^4}{32\pi^2\epsilon_0^2\hbar^2 c^2}$ (c) $\frac{v}{c} = \frac{m}{M}$ (d) $\frac{v}{c} = \frac{\hbar}{mca_0}$
10. Let \mathbb{R} be the set of all real numbers. Consider the sets $P = \{x \in \mathbb{R} : (x-1)(x^2+1) = 0\}$, $Q = \{x \in \mathbb{R} : x^2 - 9x + 2 = 0\}$ and $S = \{x \in \mathbb{R} : x = 5y \text{ for some } y \in \mathbb{R}\}$
 $S = \{x \in \mathbb{R} : x = 5y \text{ for some } y \in \mathbb{R}\}$. Then the set $(P \cap S) \cup Q$ contains
- (a) exactly two elements (b) exactly three elements
(c) exactly four elements (d) infinitely many elements

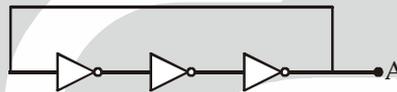
Q.11 – Q.30 carry two marks each.

11. In a population growing according to the logistic growth model
- (a) individuals reproduce according to their physiological capacity
 - (b) the per capita rate of increase approaches zero as the population nears the carrying capacity
 - (c) the number of births is always more than the number of deaths
 - (d) the birth-to-death ratio is NOT influenced by the carrying capacity
12. Which part of the genomic DNA contains the sequence corresponding to the 5' untranslated region (5' UTR)?
- (a) Exon
 - (b) Intron
 - (c) Upstream of the transcription start site
 - (d) Upstream of the promoter
13. Which one of the following is **NOT TRUE** of RNA polymerase II?
- (a) It requires a primer to initiate the transcription
 - (b) It makes an RNA copy of only one strand of a double-stranded DNA at any given time
 - (c) It does not synthesize rRNA and tRNA
 - (d) It catalyzes the polymerization of RNA only in the 5' → 3' direction
14. Choose the option that shows the correct pairing of the cellular components with their corresponding function.
- | | |
|--------------|----------------------------------|
| P. Dynein | i. Movement of organelles |
| Q. Desmosome | ii. Membrane vesicle |
| R. Endosome | iii. Beating of flagella |
| S. Kinesin | iv. Attachment of cells together |
- (a) P-iv, Q-i, R-ii, S-iii
 - (b) P-iii, Q-iv, R-ii, S-i
 - (c) P-iii, Q-i, R-ii, S-iv
 - (d) P-ii, Q-i, R-iv, S-iii
15. An enzyme shows highest activity in the pH range 2.0 – 3.0. At pH 4.0 and pH 7.0, the enzyme exhibits 50% and 1%, respectively, of its highest activity. Which of the following states of an amino acid residue in the catalytic site is most responsible for its activity profile?
- (a) A protonated Asp
 - (b) A deprotonated Asp
 - (c) A deprotonated Asn
 - (d) A protonated Asn
16. The specific productivity (q_p) of cellulase production by *Aspergillus niger* follows a linear relationship with the specific growth rate (μ) and is of the form $q_p = \alpha\mu + \beta$, where α and β are constants. Assuming that the values of α and β are 0.006 and 25, respectively, which type of product formation kinetics is **TRUE**?
- (a) Growth-dependent kinetics
 - (b) Non-growth dependent kinetics
 - (c) Both growth-and non-growth-dependent kinetics
 - (d) Inhibition kinetics
17. Choose the option that shows the correct pairing of the diseases with their corresponding causative organisms.
- | | |
|----------------------|----------------------------------|
| P. Chagas disease | i. <i>Trypanosoma gambiense</i> |
| Q. Sleeping sickness | ii. <i>Plasmodium falciparum</i> |
| R. Malaria | iii. <i>Yersinia pestis</i> |
| S. Plague | iv. <i>Trypanosoma cruzi</i> |
- (a) P-iv, Q-i, R-iii, S-ii
 - (b) P-iv, Q-i, R-ii, S-iii
 - (c) P-i, Q-iv, R-ii, S-iii
 - (d) P-i, Q-iv, R-iii, S-ii

18. Choose the option that shows the correct pairing of the products with their corresponding microorganisms
- | | |
|-------------------------|-----------------------------------|
| P. Citric acid | i. <i>Micromonospora purpurea</i> |
| Q. Polyhydroxyalkonates | ii. <i>Zymomonas mobilis</i> |
| R. Gentamycin | iii. <i>Aspergillus niger</i> |
| S. Ethanol | iv. <i>Ralstonia eutropha</i> |
- (a) P-ii, Q-iii, R-i, S-iv
(b) P-iv, Q-ii, R-iii, S-i
(c) P-iii, Q-iv, R-i, S-ii
(d) P-iii, Q-i, R-iv, S-ii
19. Determine the correctness or otherwise of the following Assertion [a] and Reason [r].
Assertion [a]. B cells secrete antibodies against a virus while cytotoxic T cells kill virus-infected cells.
Reason [r]. B cells confer active immunity while cytotoxic T cells confer passive immunity
- (a) [a] and [r] are true and [r] is the correct reason for [a]
(b) [a] and [r] are true but [r] is not the correct reason for [a]
(c) [a] is true but [r] is false
(d) [a] false but [r] is true
20. Which one of the following options shows the correct pairing of the enzyme with its corresponding application?
- | | |
|---------------------|--------------------------------|
| P. Papain | i. Gluten complex reduction |
| Q. Bromelain | ii. Immuno assay marker enzyme |
| R. Peroxidase | iii. Maltose syrup preparation |
| S. β -amylase | iv. Meat tenderizer |
- (a) P-iv, Q-i, R-ii, S-iii
(b) P-iv, Q-iii, R-i, S-ii
(c) P-iv, Q-i, R-iii, S-ii
(d) P-i, Q-ii, R-iv, S-iii
21. The rate constant for the reaction $O(g) + O_3(g) \rightarrow 2O_2(g)$ is $8.0 \times 10^{-15} \text{ cm}^3 \text{ molecule}^{-1} \text{ s}^{-1}$. The rate constant in $\text{dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$, would be
- (a) 4.8×10^{-6} (b) 4.8×10^6 (c) 4.8×10^{-9} (d) 8.0×10^6
22. The UV spectrum of 2-butanone and the UV spectrum of methyl vinyl ketone (MVK) are independently recorded and compared. Among the various λ_{max} , 185 nm, 219 nm, 277 nm and 324 nm, the absorption at $\lambda_{\text{max}} = 324 \text{ nm}$ is due to
- (a) $n \rightarrow \pi^*$ transition in 2-butanone (b) $n \rightarrow \pi^*$ transition in MVK
(c) $\pi \rightarrow \pi^*$ transition in 2-butanone (d) $n \rightarrow \sigma^*$ transition in 2-butanone
23. The compound *meso* 2, 3-dibromobutane is obtained by
- (a) electrophilic addition of HBr to (*E*)-1-bromobut-2-ene
(b) electrophilic addition of Br_2 to (*E*)-2-butene
(c) electrophilic addition of Br_2 to (*Z*)-2-butene
(d) nucleophilic addition of Br_2 to (*Z*)-1-bromobut-2-ene
24. The major product in the following reaction is



25. An archaeological sample (remains of an animal) containing ^{14}C isotope of Carbon is found to give 10 beta decays per minute per gram of Carbon. It is known that the natural abundance of ^{14}C in organic matter that is in equilibrium with the atmosphere today will give 15 beta decays per minute per gram of Carbon. The half life of ^{14}C is known to be 5730 years. The estimated age of the sample (in years) is
 (a) 3010 (b) 3350 (c) 3500 (d) 3800
26. The minimum light intensity that the human eye can perceive is 10^{-10} Wm^{-2} . The area of the opening of our eye (the pupil) is approximately 0.4 cm^{-2} . Consider yellow light with wavelength $\lambda = 600\text{nm}$. The number of photons incident on the retina per second at the minimum intensity for the eye to respond is
 (a) 1.5×10^3 (b) 5×10^3 (c) 8×10^3 (d) 1.2×10^4
27. Three NOT gates are connected in series and the output of the last gate is fed back to the input of the first one as shown in the figure. Each gate has a propagation delay of $T_d = 1$ nano second, which means that the gate requires 1 nano second to change the output after the signal arrives at the input. What is the expected output at point A?



- (a) Sine wave with a frequency of 666 MHz (b) Square wave with a frequency of 666 MHz
 (c) Random white noise (d) Square wave with a frequency of 333 MHz
28. Let nC_r denote the number $\frac{n!}{r!(n-r)!}$. Then for $n=100$, the sum of the series $1 - {}^nC_1 + {}^nC_2 - {}^nC_3 + \dots + (-1)^r {}^nC_r + \dots + (-1)^n {}^nC_n$ is
 (a) 0 (b) 1 (c) 2 (d) 1024
29. The lengths of two sides of a triangle are 2 units and 3 units and the angle included by these two sides is 60° . The length of the third side of the triangle will be
 (a) $\sqrt{5}$ units (b) $\sqrt{7}$ units (c) 4 units (d) 5 units
30. If A and B are two skew-symmetric matrices, the matrix $AB + BA$ must be
 (a) skew-symmetric (b) symmetric (c) invertible (d) Not invertible

SECTION – B

MULTIPLE SELECT QUESTIONS (MSQ)

Q.1 – Q.10 carry two marks each.

1. In a large wild flower population, assume that no new mutations occur and that no natural selection operates. What factor(s) will affect the frequency of a genotype in this population?
 (a) Non-random mating
 (b) Gene flow
 (c) Out-breeding within the population
 (d) Invasion of a new pathogen that kills a large number of individual in the population

2. What is (are) the difference(s) between microtubules and microfilaments?
- Microtubules are made up of tubulin and microfilaments are made up of intermediate filaments
 - Microtubules are important for compression resistance and microfilaments bear tension
 - Microtubules are important for the functions of cilia and flagella and the microfilaments are important for cytoplasmic streaming
 - Microtubules - muscle contraction; microfilaments - ciliary movement
3. N and N_0 represent the number of viable cells at time ' t ' during sterilization and at the start of sterilization ($t = 0$), respectively. Assuming that cell death follows first order kinetics and that k is the death rate constant, which of the following relationship(s) is/are correct?
- $N = N_0 e^{kt}$
 - $-\ln(N / N_0) = kt$
 - $N = N_0 kt^2$
 - $N - N_0 = kt$
4. Which of the following statements about antigen-antibody (Ag-Ab) complexes is (are) **TRUE**?
- Hydrogen bonds and van der Waals forces participate in Ag-Ab interactions
 - Ionic bonds and hydrophobic bonds participate in Ag-Ab interactions
 - The combined strengths of all interactions between a single antigen binding site on an antibody and a single epitope is called avidity
 - Antibody elicited by one antigen can cross react with an unrelated antigen
5. The superoxide ion, O_2^- , is produced by the reaction $K + O_2 \rightarrow KO_2$. The correct statement(s) pertaining to oxygen and superoxide ion is (are)
- oxygen is paramagnetic and has two unpaired electrons
 - the bond order in oxygen is 2
 - the bond order in superoxide is 1.5
 - the superoxide ion is not paramagnetic
6. Among the following compounds, which of these will show two singlets in their 1H -NMR spectrum?
- 1, 4-Dichlorobenzene
 - 1, 2-Dichlorobenzene
 - Dimethoxymethane
 - Methylacetate
7. Among the following pairs of co-ordination compounds, the pair(s) which represent(s) a case of "ionization isomerism" is (are)
- $[Pt(en)_2Cl_2]Br_2$ and $[Pt(en)_2Br_2]Cl_2$
 - $[Cr(NH_3)_4ClBr]NO_2$ and $[Cr(NH_3)_4ClNO_2]Br$
 - $[Co(NH_3)_6][Cr(CN)_6]$ and $[Cr(NH_3)_6][Co(CN)_6]$
 - $[Co(NH_3)_5Br]SO_4$ and $[Co(NH_3)_5SO_4]Br$
8. The "strong nuclear force" holds the protons and neutrons (nucleons) together in the nucleus of an atom. It is found that the binding energy per nucleon (for the nucleus of an element) when plotted against the mass number (A) of that element changes very little for $30 < A < 150$. The binding energy is lower for $A \ll 30$ or $A \gg 150$. This leads us to conclude that
- the strong nuclear force must oscillate with distance with a periodicity approximately same as the size of a proton or neutron
 - the fusion of two elements, both with $A \ll 30$ or fission of an element $A \gg 150$ may release energy
 - the strong nuclear force changes very slowly with distance (i.e. it is long ranged on the scale of the size of nucleus)
 - the strong nuclear force goes to zero very rapidly with distance (i.e. it is short ranged on the scale of the size of nucleus)

9. Let \vec{a} and \vec{b} be two non-zero vectors such that $|\vec{a} + \vec{b}| = |\vec{a} - \vec{b}|$. Then
- (a) \vec{a} and \vec{b} are parallel to each other (b) \vec{a} and \vec{b} are perpendicular to each other
- (c) \vec{a} is NOT a scalar multiple of \vec{b} (d) $\vec{a} \times \vec{b} = \vec{0}$
10. Let \mathbb{N} be the set of all natural numbers. Consider the relation R on \mathbb{N} given by $R = \{(m, n) : m - n \text{ is divisible by } 2\}$. Then
- (a) R is symmetric and transitive (b) R is symmetric but NOT transitive
- (c) R is reflexive but NOT symmetric (d) R is reflexive and transitive

SECTION – C

NUMERICAL ANSWER TYPE (NAT)

Q.1 – Q.10 carry one mark each.

- The pH of a 0.1M solution of monosodium succinate ($\text{pK}a_1 = 4.19$ and $\text{pK}a_2 = 5.57$) is _____
- The deactivation rate constant of an enzyme is 0.346h^{-1} . Assuming that the deactivation process follows first order kinetics, the half life of the enzyme in minutes is _____
- An enzyme preparation containing 10 mg/ml protein shows a specific activity of 50 U/mg. The initial velocity of reaction in a standard 1ml reaction mixture containing 10 μ l of the preparation in $\mu\text{mol}\cdot\text{ml}^{-1}\cdot\text{min}^{-1}$ is _____
- The number of peaks in the ^{13}C -NMR spectrum of CDCl_3 is _____
- The number of phosphorous-hydrogen bonds in H_3PO_2 is _____
- A man weighing 70kg stands on a weighing scale which is placed in an elevator. The elevator is moving up towards its destination floor with a velocity of 1.0ms^{-1} . As it approaches the destination floor it starts slowing down, such that it comes to rest in 2 seconds. Assuming the acceleration due to gravity, $g = 9.8\text{ms}^{-2}$, the reading of the weighing scale just *before* the elevator comes to rest is _____
- A 50-metre tall antenna transmits at 107 MHz (one of the FM radio broadcast frequencies). Calculate the maximum distance from the antenna at which the transmitted signal can be heard. Ignore atmospheric attenuation and give your answer correct to the nearest kilometer only. You are given that the radius of the earth is 6400 km.
- The total number of mappings from the set $\{1, 2\}$ to the set $\{3, 4, 5, 6, 7\}$ is _____
- The value of the complex number $(1+i)^{150} + (1-i)^{150}$ is _____
- Let the function $f : \mathbb{R} \rightarrow \mathbb{R}$ be defined by $f(x) = \begin{cases} \frac{\tan x}{x} & \text{if } x \neq 0 \\ k & \text{if } x = 0 \end{cases}$

If f is continuous at $x=0$, then the value of k must be equal to _____

Q.11 – Q.20 carry two marks each.

- Assume that the gene *UNC* is essential for the coordinated movement of a nematode and that the wild-type allele *U* is dominant over the mutant allele *u*. Similarly, the wild-type allele *D* of another gene *DPY*, which is responsible for the normal body length, is dominant over the mutant allele *d*. Assume the *UNC* and *DPY* are on two different chromosomes. If a female of genotype *UUDD* mates with a male of the genotype *uudd*, the percentage of the F2 progeny that will display uncoordinated movement but will have normal body length is _____

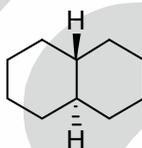
12. The pH of gastric juice in the stomach is 2.0. However the pH inside the cells that line the stomach is 7.0. For transport of protons from inside the cell to the stomach, the free energy change (ΔG) in kJmol^{-1} at 37°C is _____

[Assume Universal Gas constant $R = 8.314 \text{ Jmol}^{-1}\text{K}^{-1}$]

13. A solution containing NAD^+ and NADH has an optical density of 0.233 at 340 nm and 1.000 at 260 nm. While this solution absorbs at 260 nm, NADH alone absorbs at 340 nm. All measurements are carried out in a 1-cm cuvette. Given the extinction coefficients (ϵ) (see the table below), the concentration of the oxidized form of the cofactor in μM is _____

| Compound | $\epsilon(\text{M}^{-1} \text{cm}^{-1})$ | |
|----------------|------------------------------------------|--------|
| | 260 nm | 340 nm |
| NAD^+ | 18000 | 0 |
| NADH | 15000 | 6220 |

14. *Drosophila melanogaster* is a diploid organism having 8 chromosomes. The number of combinations of chromosomes which are possible in its gametes is _____
15. The number of equatorial hydrogens in the following structure is _____



16. The axis of rotation of the earth makes an angle of 66.5° with the plane containing the Earth's orbit around the Sun (called the plane of the ecliptic). If this angle were 50° , then the area of the Earth's surface from which a "midnight Sun" (24 hour daylight) can be observed would change. The ratio of the new area to the previous area is _____
17. A nuclear power plant generates 1000 Megawatts (MW) of electrical power and used half of its fuel supply in 5 years. The reactor uses ^{235}U with 33% efficiency for the conversion of heat released by nuclear fission to electrical power. Each atom of ^{235}U releases 200 MeV of energy. How many tons of ^{235}U did the reactor start with? (1 ton = 1000 kg; Avogadro number = $6.023 \times 10^{23} \text{ mol}^{-1}$)
18. A bat emitting ultrasound at 50 kHz is flying directly towards a solid wall with a speed of 3ms^{-1} . If the speed of sound in air is 330ms^{-1} , the frequency of the reflected signal (in kHz) heard by the bat will be _____
19. A circle is given by the equation $2x^2 + 2y^2 + 8x - 20y + 10 = 0$. The area of a square whose side equals the radius of the circle is _____

20. The value of the integral $\int_0^\pi |\cos x| dx$ is _____

