IIT JAM 2019 Biological Sciences (BL) Question Paper

Time Allowed :3 Hours	**Maximum Marks :**100	**Total questions :**60

General Instructions

General Instructions:

i) All questions are compulsory. Marks allotted to each question are indicated in the margin.

ii) Answers must be precise and to the point.

iii) In numerical questions, all steps of calculation should be shown clearly.

iv) Use of non-programmable scientific calculators is permitted.

v) Wherever necessary, write balanced chemical equations with proper symbols and units.

vi) Rough work should be done only in the space provided in the question paper.

1. Tropic hormones or tropins are secreted by

(A) adrenal medulla

(B) anterior pituitary

(C) hypothalamus

(D) posterior pituitary

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2. Which one of the following is necessary for evolution to be driven by genetic drift?

(A) Migration

(B) Natural selection

(C) Rapid mutation

(D) Small population size

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3. Biotin deficiency can arise due to consumption of diet rich in

(A) raw eggs

(B) raw fish

(C) raw meat

(D) seaweeds

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4. In a plant species, yellow seed colour (Y) is completely dominant over white (y). A genetic cross between plants with yellow seeds and plants with white seeds yielded a progeny of 48 yellow-seeded and 52 white-seeded plants. The genotypes of the yellow-seeded and white-seeded parent plants, respectively, are most likely to be

(A) YY and yy

(B) Yy and yy

(C) Yy and Yy

(D) YY and Yy

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5. Thomas Cech discovered RNA self-splicing in

(A) Caenorhabditis elegans

(B) Saccharomyces cerevisiae

(C) Schizosaccharomyces pombe

(D) Tetrahymena thermophila

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6. The core glycan moiety of N-linked glycoproteins contains

(A) fifteen mannose units

(B) five N-acetyl glucosamine units

(C) three glucose units

(D) three N-acetyl neuraminic acid units

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7. Organophosphate pesticides kill insects by inhibiting

(A) acetylcholinesterase

(B) carbonic anhydrase

(C) DNA polymerase

(D) pyruvate kinase

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8. Which one of the following conditions leads to an approximately 50-fold increase in RNA transcription of the lac operon? (CRP stands for cyclic AMP [cAMP] receptor protein)

(A) Q and S

(B) P and R

(C) P and S

(D) Q and R

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9. Which one of the following photosynthetic organisms does not release oxygen as a by-product of the light reaction?

(A) Algae

(B) Cyanobacteria

(C) Euglena

(D) Sulphur bacteria

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10. In plant systematics, which one of the following species belongs to the branch at the very base of the angiosperm phylogenetic tree?

(A) Amborella trichopoda

(B) Illicium floridanum

(C) Magnolia grandiflora

(D) Nymphaea stellata

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11. The molecular weight (Da) of the zwitterionic form of the peptide GAGAGAGA is closest to

(A) 512

(B) 530

(C) 656

(D) 782

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12. If $y = x^2$, then dx/dy is

(A) 2x

(B) 2y

(C) $\pm\frac{1}{2\sqrt{x}}$

(D) $\pm\frac{1}{2\sqrt{y}}$

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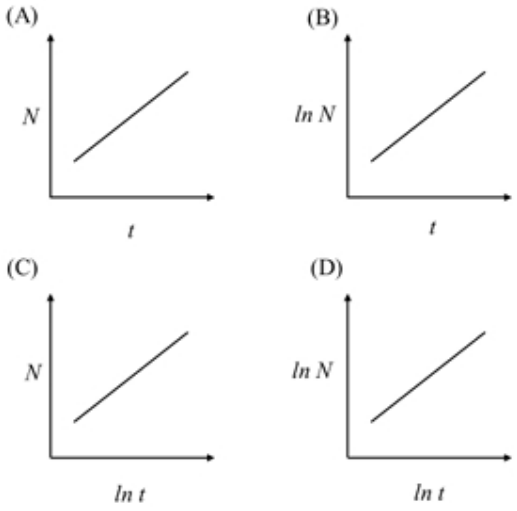
13. Which one of the following plots represents exponential growth?



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14. Naive T lymphocytes can be stimulated by the activated dendritic cells that bear

(A) a specific antigenic peptide alone

(B) a specific antigenic peptide and CD11c

(C) a combination of co-stimulatory molecules and a non-specific antigenic peptide

(D) a combination of co-stimulatory molecules and a specific antigenic peptide

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15. In rearrangement of immunoglobulin heavy chain, N-nucleotides

(A) are added by the enzyme terminal deoxynucleotidyl transferase

(B) form a palindromic sequence that is added to the end of gene segment

(C) form a palindromic sequence that is added to the single stranded end of the coding DNA

(D) are added by the enzyme DNA-dependent DNA polymerase

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16. Which one of the following matches is CORRECT between the microorganisms given in Group A with their requirement of oxygen in Group B?

Group A	**Group B**
(P) *Micrococcus luteus*	(i) Obligate anaerobe
(Q) *Spirillum volutans*	(ii) Facultative aerobe
(R) *Methanobacterium formicicum*	(iii) Obligate aerobe
	(iv) Microaerophilic

(A) P: iii, Q: iv, R: i

(B) P: iii, Q: ii, R: iv

(C) P: ii, Q: iv, R: i

(D) P: iii, Q: ii, R: i

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17. Which one of the following is TRUE for the function $y = x^2 + 1$?

(A) It does not intersect the X-axis at all

(B) It intersects the X-axis at $x = -1$

(C) It intersects the X-axis at $x = +1$

(D) It is tangential to the X-axis

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18. Match the metabolic pathways in Group A with corresponding enzymes in Group B

Group A	**Group B**
(P) Glycolysis	(i) Pyruvate carboxylase
(Q) Gluconeogenesis	(ii) Enolase
(R) Hexose monophosphate shunt	(iii) Isocitrate lyase
(S) Glyoxylate cycle	(iv) Glucose-6-phosphate dehydrogenase

(A) P: i, Q: iv, R: iii, S: ii

(B) P: ii, Q: i, R: iv, S: iii

(C) P: i, Q: iv, R: i, S: iii

(D) P: iii, Q: iv, R: ii, S: i

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19. Which one of the following statements is INCORRECT for competitive inhibition in an enzyme catalysed reaction?

(A) Apparent K_m increases

(B) Apparent V_{max} decreases

(C) Inhibitor binds to the active site

(D) Inhibition decreases with an increase in [S]

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20. In a human cell, β-oxidation of a saturated fatty acyl CoA molecule produced 8 acetyl CoA, 7 HO and 28 ATP. The oxidised fatty acyl CoA is

(A) octanoyl CoA

(B) oleoyl CoA

(C) palmitoyl CoA

(D) stearoyl CoA

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21. Match the diseases in Group A with their corresponding causative microorganisms in Group B

Group A	**Group B**
(P) Hansen's disease	(i) Mycobacterium leprae
(Q) Sleeping sickness	(ii) Treponema pallidum
(R) Syphilis	(iii) Borrelia burgdorferi
(S) Lyme disease	(iv) Trypanosoma brucei

(A) P: iii, Q: iv, R: i, S: ii

(B) P: iv, Q: ii, R: iii, S: i

(C) P: ii, Q: iv, R: i, S: iii

(D) P: iii, Q: ii, R: iv, S: i

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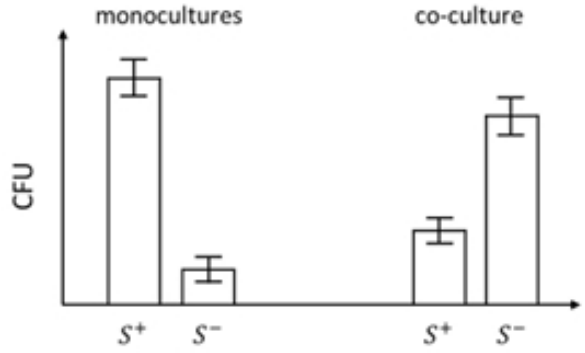
22. In an experiment to examine the role of exopolymetric substances (EPS) on bacterial growth, a wild-type strain (S) and a mutant strain deficient in EPS production (S) were grown in monocultures as well as in co-culture (in equal proportion of S and S). The CFU (colony forming units) of these cultures measured after 24 hours are shown in the following figure.



Which one of the following phenomena best describes the interaction between the wild-type strain (S) and mutant strain (S)?

(A) Amensalism

(B) Cooperation

(C) Commensalism

(D) Mutualism

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23. If a fossil that has been discovered recently contains 0.2% of the ^{14}C (t/ = 5,730 years) that was present when the fossil was formed, then the age of the fossil in years is likely to fall in the range of

(A) 25,000 – 35,000

(B) 35,000 – 45,000

(C) 45,000 – 55,000

(D) 55,000 – 65,000

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24. A photosynthetic algal filament is illuminated with white light that has passed through a prism such that the left and the right ends of the filament receive violet and red lights, respectively. The amount of oxygen released by this filament will be

(A) high at the left end and progressively reducing towards the right

(B) high at the right end and progressively reducing towards the left

(C) high at both ends and progressively reducing towards the middle

(D) high in the middle and progressively reducing towards both ends

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25. Which one of the following statements is TRUE for dynein and kinesin family of motor proteins?

(A) Both dynein and kinesin are only (+) end directed motors

(B) Dynein is (-) end directed and kinesin can be either (+) or (–) end directed

(C) Both dynein and kinesin are only (–) end directed motors

(D) Kinesin is (+) end directed and dynein can be either (+) or (–) end directed

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26. Which one of the following statements is TRUE about flagella?

(A) Flagella in both prokaryotes and eukaryotes are made of flagellin

(B) Flagella in prokaryotes are made of flagellin while in eukaryotes are made of tubulin

(C) Flagella in both prokaryotes and eukaryotes are made of tubulin

(D) Flagella in prokaryotes are made of tubulin while in eukaryotes are made of flagellin

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27. Caffeine is a plant-based drug that

(A) does not intercalate into DNA double helix

(B) inhibits cyclic AMP (cAMP) phosphodiesterase activity

(C) inhibits epinephrine response

(D) reduces the level of cellular cAMP

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28. 2,4-Dinitrophenol (DNP) is an uncoupler that

(A) cannot freely pass through plasma membrane

(B) enhances ATP production

(C) is a non-toxic compound at high dose

(D) makes the inner mitochondrial membrane leaky to protons

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29. Which one of the following statements is INCORRECT about the prokaryotic and eukaryotic organisms on the Earth?

(A) Prokaryotes have more sequence diversity in their DNA than do eukaryotes

(B) Prokaryotes outnumber eukaryotes

(C) Prokaryotes survive in more extreme environments than do eukaryotes

(D) The cumulative biomass of prokaryotes is less than that of eukaryotes

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30. Which is the CORRECT chronological order, from the least recent to the most recent, of the four evolutionary events listed below?

P. Earliest evidence of terrestrial arthropods

Q. Appearance of Ediacaran fauna

R. Extinction of the large, non-flying dinosaurs

S. Origin of mammals

(A) P, Q, R, S

(B) Q, P, R, S

(C) P, Q, S, R

(D) Q, P, S, R

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31. Which of the following changes would cause a shift in the membrane potential of a neuronal cell from -70 mV to -50 mV?

(A) A decrease in K^+ permeability

(B) An increase in Na^+ permeability

(C) An increase in K^+ permeability

(D) A decrease in Na^+ permeability

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32. In this system of two reactions, $A \rightarrow 2B$ and $B \rightarrow 2C$, which of the following statements is/are TRUE at steady-state?

(A) The rate of consumption of A is four times the rate of production of C

(B) The rate of consumption of B is twice the rate of production of C

(C) The rate of production of B is the same as the rate of consumption of B

(D) The rate of production of C is four times the rate of consumption of A

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33. The function $f(x) = x^2 - 6x + 8$ is positive when

(A) $x < 2$

(B) $2 < x < 4$

(C) $-6 \leq x \leq 8$

(D) $x > 4$

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34. A typical α-helix in a native polypeptide chain has

(A) 3.6 amino acid residues per turn

(B) A rise of 5.4 Å per turn

(C) High proline and glycine content

(D) ϕ value of -57° and ψ value of -47°

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35. Insulin action on a target cell causes an increase in

(A) Acetyl CoA carboxylase

(B) Glucokinase

(C) Glucose-6-phosphate dehydrogenase

(D) GLUT4 transporter

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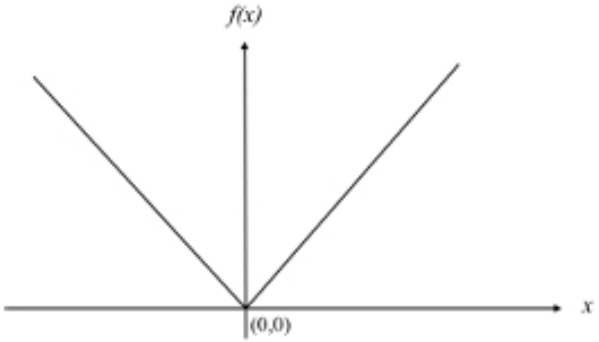
36. Which of the following statements is/are TRUE for the function $f(x)$ shown in the figure given below?



(A) $f(x)$ is continuous at $x = 0$

(B) $f(x)$ is not continuous at $x = 0$

(C) $f(x)$ is differentiable at $x = 0$

(D) $f(x)$ is not differentiable at $x = 0$

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37. Which of the following coenzymes is/are present in the pyruvate dehydrogenase complex?

(A) Coenzyme A

(B) Lipoate

(C) Pyridoxal phosphate

(D) Thiamine pyrophosphate

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38. Which of the following disorders in humans is/are due to a defect/deficiency in

enzymes involved in the urea cycle?

(A) Alkaptonuria

(B) Argininemia

(C) Argininosuccinic acidemia

(D) Phenylketonuria

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39. Ricin, a protein from castor beans, causes toxicity in humans by

(A) Depurinating the 23S ribosomal RNA

(B) Inactivating the 60S ribosomal subunit

(C) Inhibiting the elongation factor eEF2

(D) Intercalating DNA

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40. During photosynthesis in higher plants, oxygen is produced

(A) By splitting water

(B) In Photosystem I

(C) In Photosystem II

(D) Only in the presence of light

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41. The function $f(x) = \sin(x)e^{-x}$ is equal to zero in the range $0 < x < 2\pi$ for $x =$ ___ radians (round off to 2 decimal places)

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42. A spherical bacterium has a diameter of 2 µm. Its volume to surface area ratio is equal to ___ µm (round off to 2 decimal places)

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43. The value of the integral $\int_0^\infty e^{-y}\,dy$ is equal to ___ (round off to 2 decimal places)

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44. The velocity of an enzyme-catalysed reaction following Michaelis–Menten kinetics, at the substrate concentration equal to $0.3 \times K_m$, is equal to ___ $\times V_{\max}$ (round off to 2 decimal places)

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45. The angle (in degrees) between the hour hand and the minute hand of a 12-hour clock showing 6:30 is ___ (round off to 1 decimal place)

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46. Values of ΔG_f^0 (standard Gibbs free energy of formation) for molecules A, B, and C are

$$\Delta G_f^0(A) = -34\,\text{kJ/mol}, \quad \Delta G_f^0(B) = 84\,\text{kJ/mol}, \quad \Delta G_f^0(C) = -100\,\text{kJ/mol},$$

respectively. The ΔG^0 for the reaction $A + B \rightarrow C$ would be ___ kJ/mol (round off to 1 decimal place)

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47. A bacterial population in the log-phase grows from 4×10^6 cells to 8.64×10^6 cells in 20 minutes. The doubling time of the bacterium is ___ minutes (round off to 1 decimal place)

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48. Tryptophan (Trp) is encoded by UGG, phenylalanine (Phe) is encoded by UUU and UUC, isoleucine (Ile) is encoded by AUU, AUC, and AUA, and glycine (Gly) is encoded by GGU, GGC, GGA and GGG. The maximum number of RNA segments with unique sequences that can encode the polypeptide Ile-Phe-Trp-Ile-Gly-Trp would be ___

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49. In an examination consisting of 100 multiple choice questions, each question has four choices out of which only one is correct. A student scores +1 for each correct answer and a negative mark of -1/5 for each wrong answer. The correct choices are uniformly distributed across the four choices. If an unprepared student always selects the first choice for each question, then the expected value of the student's total score in the examination would be ___ (round off to 1 decimal place)

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50. In a large insect population, males and females are equally abundant. If a student collects four insects from this population at random, the probability that all of them are male is ___ (round off to 2 decimal places)

51. An E. coli cell with an internal volume of 2 femtolitres contains 10 molecules of a repressor protein in its cytosol. The concentration of the repressor protein is ___ nM (round off to 1 decimal place)

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52. The growth rate of a bacterial culture is given by $x\left(1-\frac{x}{100}\right)$, where x is the density of the culture. The growth rate is maximum when the density is equal to ___ (round off to 1 decimal place)

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53. A hypothetical plant forms 10 leaves, each of which is perfectly circular with 10 cm diameter. If the total number of stomata made by all these leaves is 7.85×10^6, then the stomatal density in these leaves would be ___ / mm^2 (round off to 1 decimal place)

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54. In a diploid population at Hardy-Weinberg equilibrium, the locus A has two alleles A_1 and A_2. If the frequency of A_1A_1 genotype is 0.01, then the frequency of the allele A_2 is ___ (round off to 2 decimal places)

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55. In the following figure, the radius of the circle circumscribing the regular hexagon is 2 cm. The area of the shaded region is ___ cm^2 (round off to 2 decimal places)

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56. The complete oxidation of one mole of palmitoyl CoA yields 23 moles of water and 16 moles of carbon dioxide. The amount of water that can be produced from 1 kg of tripalmitate is ___ mL (round off to 2 decimal places)

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57. If x, y, and z are all positive and $x + y + z = 9$, the maximum value of xyz is ___

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58. Evaluate the limit $\lim_{x\to 1} \frac{x^2-1}{\sqrt{x}-1}$

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59. In the second-order reaction $2A \rightarrow B$, the initial concentration of A is 1.0 M and after 30 minutes, the concentration of A is 0.5 M. The rate constant of the reaction is ___ L/mol/h (round off to 2 decimal places)

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60. Water from a full cylindrical vessel of height h and of unknown diameter is completely emptied to precisely fill two cylindrical vessels of the same diameter d and heights h and $3h$. The diameter of the original vessel is ___ $\times d$ (round off to 2 decimal places)
