89

QUESTION PAPER
SERIES CODE

A

Registration No. :

Centre of Exam. : _____

Name of Candidate : _____

_____
Signature of Invigilator

ENTRANCE EXAMINATION, 2014
Pre-Ph.D./Ph.D. COMPUTATIONAL BIOLOGY AND BIOINFORMATICS
[Field of Study Code : CBBP (166)]

Time Allowed : 3 hours   *Maximum Marks* : 70

INSTRUCTIONS FOR CANDIDATES

Candidates must read carefully the following instructions before attempting the Question Paper :

(i) Write your Name and Registration Number in the space provided for the purpose on the top of this Question Paper and in the Answer Sheet.

(ii) **Please darken the appropriate Circle of Question Paper Series Code on the Answer Sheet.**

(iii) The Question Paper consists of two Parts : Part—A and Part—B.

(iv) Part—A contains twenty (20) questions. Answer **all** questions. Each correct answer carries 1 mark and **0·25 mark will be deducted for every wrong answer.**

(v) Part—B has **five** sections of twenty-five (25) questions each. Candidates may choose any **one** section and answer twenty-five (25) questions. Each question carries **2** marks and **0·5 mark will be deducted for every wrong answer.**

(vi) Answer all the questions in the Answer Sheet provided for the purpose by darkening the correct choice, i.e., (a) or (b) or (c) or (d) with BALLPOINT PEN only against each question in the corresponding circle.

(vii) In case you think none of the possible answers are correct, mark the correct answer which you think is closest to the correct one.

(viii) Answer written by the candidates inside the Question Paper will not be evaluated.

(ix) Simple Calculators and Log Tables may be used.

(x) Pages at the end have been provided for Rough Work.

(xi) Return the Question Paper and Answer Sheet to the Invigilator at the end of the Entrance Examination. **DO NOT FOLD THE ANSWER SHEET.**

INSTRUCTIONS FOR MARKING ANSWERS

1. Use only Blue/Black Ballpoint Pen (do not use pencil) to darken the appropriate Circle.

2. Please darken the whole Circle.

3. Darken ONLY ONE CIRCLE for each question as shown in example below :

Wrong	Wrong	Wrong	Wrong	Correct
● ⓑ © ●	ⓐ̸ ⓑ © ⓓ	ⓐ̸ ⓑ © ⓓ̸	⊙ ⓑ © ●	ⓐ ⓑ © ●

4. Once marked, no change in the answer is allowed.

5. Please do not make any stray marks on the Answer Sheet.

6. Please do not do any rough work on the Answer Sheet.

7. Mark your answer only in the appropriate space against the number corresponding to the question.

8. **Ensure that you have darkened the appropriate Circle of Question Paper Series Code on the Answer Sheet.**

/89-**A**

PART—A

Answer all questions

1. If $x = a \sin\left(\omega t + \dfrac{\pi}{6}\right)$ and $x' = a\cos\omega t$, then what is the phase difference between the two waves?

(a) $\dfrac{\pi}{3}$

(b) $\dfrac{\pi}{6}$

(c) $\dfrac{\pi}{2}$

(d) None of the above

2. Two spheres of same material have radii r_1 and r_2. They are heated to same temperature and kept in same enclosure at low temperature. Their rates of loss of heat are in the ratio

(a) $\dfrac{r_2^2}{r_1^2}$ (b) $\dfrac{r_1^2}{r_2^2}$

(c) $\dfrac{r_1}{r_2}$ (d) $\dfrac{r_2}{r_1}$

3. A geostationary satellite is orbiting the earth at a height of $6R$ above the surface of the earth, R being the radius of the earth. The time period of another satellite at a height of $2.5R$ from the surface of the earth is

(a) $6\sqrt{2}$ hr   (b) 6 hr

(c) $5\sqrt{2}$ hr   (d) 10 hr

4. The speed of sound in air is 350 m/s. The fundamental frequency of an open pipe of length 50 cm is

(a) 100 Hz

(b) 250 Hz

(c) 350 Hz

(d) 400 Hz

5. Which of the following species has shortest bond length?

(a) O_2^+ (b) O_2^{2+}

(c) O^- (d) O_2^-

6. The statement, "If you allow the ice in a full glass of ice water to melt, the glass will overflow"

   (a) is false

   (b) is true

   (c) depends on the shape of the glass

   (d) depends on the type of ice

7. The number of isomers of C_5H_{12} is

   (a) 3

   (b) 2

   (c) 1

   (d) 0

8. In C_3H_4, the hybridizations of the carbons are

   (a) sp^2 and sp

   (b) sp^3 and sp

   (c) sp^2 and sp^3

   (d) None of the above

9. A compiler does **not** detect

   (a) syntax errors

   (b) file include errors

   (c) run-time errors

   (d) All of the above

10. The difference between while and do-while loop is

    (a) do-while will be executed at least once

    (b) while will be executed at least once

    (c) while will terminate when a condition is true

    (d) do-while will terminate when a condition is true

11. In dynamic memory allocation

    (a) the amount of memory to be allocated is known beforehand

    (b) the memory has to be released by the programmer

    (c) the memory has to be released by the system stack

    (d) the memory is allocated from the system stack

12. Which of the following is *not* a sorting algorithm?

    (a) Radix sort

    (b) Heapsort

    (c) Quicksort

    (d) Intersort

13. The stage in which daughter chromosomes move toward the poles of the spindle is

    (a) anaphase

    (b) metaphase

    (c) prophase

    (d) telophase

14. Ribosomal RNA is actively synthesized in

    (a) nucleoplasm

    (b) ribosomes

    (c) lysosomes

    (d) nucleolus

15. A compound formed in an organism for inhibiting growth of another organism is

    (a) antigen

    (b) antibody

    (c) antibiotic

    (d) antiallergic

16. In *Drosophila*, the sex is determined by

    (a) the ratio of pairs of X chromosomes to the pairs of autosomes

    (b) X and Y chromosomes

    (c) the ratio of number of X chromosomes to the sets of autosomes

    (d) whether the egg is fertilized or developed parthenogenetically

17. The value of

$$\frac{d}{dx}\left(\frac{4x^4 - 2x}{4x^4 + 2x}\right)$$

is

(a) $\dfrac{24x^2 - 1}{(4x^3 + 2)^2}$

(b) $\dfrac{48x^2 - 1}{(4x^3 + 2)^2}$

(c) $\dfrac{12x^2}{(2x^3 + 1)^2}$

(d) $\dfrac{24x^2}{(4x^3 + 2)^2}$

18. The value of

$$\int 4x^2 \sqrt{x^3 + 4}\, dx$$

is

(a) $\dfrac{8}{3}(x^3 + 4)^{(3/2)} + C$

(b) $\dfrac{16}{9}(x^3 + 4)^{(3/2)} + C$

(c) $\dfrac{8}{9}(x^3 + 4)^{(3/2)} + C$

(d) $\dfrac{4}{3}\dfrac{1}{\sqrt{x^3 + 4}} + C$

19. Tickets numbered 1 to 20 are mixed up and then a ticket is drawn at random. What is the probability that the ticket drawn has a number which is a multiple of 3 or 5?

    (a) 1/2   (b) 2/5

    (c) 8/15   (d) 9/20

20. Given that u is a vector of length 2, v is a vector of length 3 and the angle between them when placed tail to tail is 45°. Which option is closest to the exact value of $u \cdot v$?

    (a) 4·5   (b) 6·2

   (c) 4·2   (d) 5·1

PART—B

Section—A

(Biology)

21. Crystal violet is used to

    (a) stain gram-positive bacteria as it binds to peptidoglycan

    (b) stain gram-negative bacteria as it binds to peptidoglycan

    (c) bind to the lipid in the plasma membrane and used as a counterstain in Gram's method

    (d) differentially stain the inner membrane in bacteria

22. Agarose is sourced from

    (a) chemical treatment of gelatin

    (b) Rhodophyta using heat extraction

    (c) chemical synthesis of simpler polysaccharides

    (d) polymerization of a mixture of glucose and fructose

23. Functional groups of the nonessential amino acid residues that are suitable for the immobilization process are

    (a) free α-, β- or γ-carboxyl groups

    (b) α or β amino groups

    (c) phenyl, hydroxyl, sulfhydryl or imidazole groups

    (d) All of the above

24. Which of the following microscopy methods can be used to monitor cellular dynamics and localization?

    (a) Phase contrast

    (b) Differential interference contrast

    (c) Laser scanning confocal

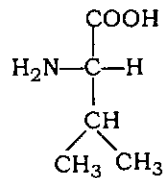   (d) Electron

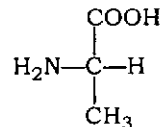**25.** Which of the following structures is the amino acid valine?

COOH
H₂N—C—H
CH₂
CH
CH₃ CH₃
(A)

COOH
H₂N—C—H
CH
CH₃ CH₂CH₃
(B)

COOH
H₂N—C—H
CH
CH₃ CH₃
(C)
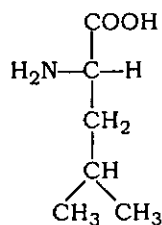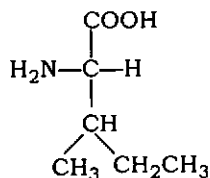
COOH
H₂N—C—H
CH₃
(D)

(a) A

(b) B

(c) C

(d) D

26. Which of the following reagents is *not* routinely required in the polymerase chain reaction?

(a) Taq DNA polymerase

(b) DNA ligase

(c) Oligonucleotide primers

(d) Denaturation using heating

27. A Southern blot is used to describe detection of

(a) sequence-specific DNA by hybridization with a DNA probe

(b) sequence-specific RNA by hybridization with a DNA probe

(c) protein using specific labelled antibodies

(d) carbohydrate using iodine

28. In eukaryotes, approximately what length of DNA is wound around a core complex of histones to form a nucleosome?

(a) 360 bp

(b) 30 bp

(c) 27 bp

(d) 180 bp

29. In enzyme kinetics, which of the equations below is the Lineweaver-Burke equations, commonly used in the measurement of enzyme steady-state kinetics to identify K_m and V_{max}?

(a) $\dfrac{1}{v_0} = \dfrac{K_m}{V_{max}} \times \dfrac{1}{[S]} + \dfrac{1}{V_{max}}$

(b) $\dfrac{[S]}{v_0} = \dfrac{K_m}{V_{max}} + \dfrac{[S]}{V_{max}}$

(c) $\dfrac{v_0}{[S]} = \dfrac{V_{max}}{K_m} + \dfrac{v_0}{K_m}$

(d) None of the above

30. Which one of the following statements about the elongation phase of protein synthesis is true?

(a) At least five high-energy phosphoryl groups are expended for each peptide bond formed

(b) Peptidyl transferase is a ribozyme

(c) Elongation factor EF-Tu facilitates translocation

(d) During elongation, incoming aminoacylated tRNAs are first bound in the P site

31. The edible portion of the coconut is

(a) pericarp

(b) mesocarp

(c) endosperm

(d) seed coat

32. —— is the term used when bacteria secrete toxins at high density to check population size.

(a) Quorum sensing

(b) Interspecies competition

(c) Allelopathy

(d) Apoptosis

33. The biomass pyramid is inverted in

(a) forest ecosystem

(b) grassland ecosystem

(c) freshwater ecosystem

(d) tundra

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34. Which measure is used to determine whether a population is evolving or not?

(a) Degree of evolution

(b) Correlation coefficient of the network

(c) Hardy-Weinberg equation

(d) Proportion of acquired mutations

35. Which sequencing method produces the longest read length?

(a) Pyrosequencing

(b) Single molecule real-time sequencing

(c) Sequencing by synthesis

(d) Sanger sequencing

36. Which method is used to estimate the variation and abundance of organisms in a metagenomic sequencing experiment?

(a) BLAST against ribosomal RNA

(b) Ubiquitous gene analysis

(c) tRNA sequence similarity

(d) Codon usage

37. Which measures are found in an alpha helix in proteins?

(a) i, $i+4$ hydrogen bonds; helical pitch of 5·4 angstroms

(b) i, $i+3$ hydrogen bonds; helical pitch of 6·0 angstroms

(c) i, $i+5$ hydrogen bonds; helical pitch of 5·0 angstroms

(d) i, $i+2$ hydrogen bonds; helical pitch of 3·6 angstroms

38. Which one of the following equations describes the enthalpy of combustion of glucose?

(a) $C_6H_{12}O_6(s) \rightarrow 6C(s) + 6H_2O(l)$

(b) $C_6H_{12}O_6(s) \rightarrow 2C_2H_5OH(l) + 2CO_2(g)$

(c) $C_6H_{12}O_6(s) + 3O_2(g) \rightarrow 6CO_2(g) + 6H_2(g)$

(d) $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(g)$

39. Which of the following cloning vectors is induced by IPTG (isopropyl-β thiogalactopyranoside)?

(a) pBR322

(b) M13

(c) pUC18

(d) Cosmids

40. Which of the following statements is false in centrifugation?

(a) The more dense a biological structure is, the faster it sediments in a centrifugal field

(b) The denser the biological buffer system is, the slower the particle will move in a centrifugal field

(c) The smaller the frictional coefficient is, the slower the particle will move

(d) The greater the centrifugal force is, the faster the particle sediments

41. Which of the following statements is true?

(a) The most stable conformation of a drug is also the active conformation

(b) The active conformation is the most reactive conformation of a structure

(c) The active conformation is the conformation adopted by a drug when it binds to its target binding site

(d) The active conformation can be determined by conformational analysis

42. Which of the following statements is true in de novo drug design?

(a) The design of rigid molecules is superior to flexible ones

(b) Molecules should be designed to fit as snugly as possible into the target binding site

(c) Molecules that have to adopt an unstable conformation in order to bind should be rejected

(d) Desolvation energies can be ignored since they are likely to be the same for different molecules having the same pharmacophore

43. What is the correct developmental order for the following?

1. Neural crest

2. Notochord

3. Neural plate

4. Neural tube

5. Neural groove

(a) 3-2-5-4-1

(b) 3-5-4-2-1

(c) 2-3-5-4-1

(d) 5-2-1-4-3

44. Which of the following genes is responsible for resistance against chilling?

(a) Glycerol-1-phosphate acyltransferase

(b) Polygalacturonase

(c) ACC deaminase

(d) Sucrose phosphate synthase gene

45. Which of the following reagents is *not* commonly used in Enzyme-linked Immunosorbent Assays (ELISA)?

(a) Solid phase immobilization using a coating antibody

(b) Hapten-conjugated carrier proteins

(c) Enzyme substrate involving a colour change

(d) Antibody enzyme conjugate labelled with a reporter enzyme

Section—B

(Chemistry)

46. The statement, "Generally hydrogen bond in gas phase is stronger than that in water at room temperature" is

   (a)   not true

   (b)   true

   (c)   There is no hydrogen bond in gas phase

   (d)   No general conclusion can be made

47. Quantum mechanical tunneling implies

   (a)   penetration of wave function through a classically forbidden region

   (b)   having a tunnel in the potential energy surface

   (c)   electrons are moving through a tunnel

   (d)   It has no meaning

48. Harmonic oscillator is a model for

   (a)   molecular rotation

   (b)   molecular vibration

   (c)   diffusion

   (d)   translation

49. Equipartition of energy means that at equilibrium at a temperature T

   (a)   each quadratic term in the energy expression will contribute $\frac{1}{2} kT$ to the average energy

   (b)   only the quadratic terms in the potential energy will contribute $\frac{1}{2} kT$ to the average energy

   (c)   only the quadratic terms in the kinetic energy will contribute $\frac{1}{2} kT$ to the average energy

   (d)   the energy is equally distributed between kinetic and potential energies

50. The normal modes of vibrations are

   (a)   the independent modes of vibration

   (b)   the dependent modes of vibration

   (c)   all vibrations irrespective of dependent or independent

   (d)   vibrations which normally occur at room temperature

51. The structure of NH_3 is

(a) tetrahedral

(b) pyramidal

(c) interconvert between tetrahedral and pyramidal

(d) neither tetrahedral nor pyramidal

52. The hybridization of carbons in graphene is

(a) sp^3

(b) sp^2

(c) both sp^3 and sp^2

(d) neither sp^2 nor sp^3

53. The point group of *cis*-planar configuration of H_2O_2 is

(a) C_{2v}

(b) C_{2h}

(c) D_{2h}

(d) C_2

54. If the plane of reflection is xy, then the matrix describing the reflection is

(a) $\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$

(b) $\begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

(c) $\begin{pmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$

(d) $\begin{pmatrix} 0 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & -1 \end{pmatrix}$

55. The probability to find a particular structure in canonical ensemble is proportional to

(a) $\exp(-E/kT)$

(b) $\exp(+E/kT)$

(c) All structures have equal probability

(d) $\exp(-E + PV/kT)$

56. Coulomb's law is valid

(a) for medium with uniform dielectric

(b) for medium with variable dielectric

(c) under any condition

(d) Never valid

57. Which of the following statements is *not* true?

(a) A catalyst reduces the activation barrier of a reaction

(b) A catalyst decreases the value of equilibrium constant

(c) A catalyst does not affect the equilibrium constant

(d) A catalyst increases the speed of a reaction

58. Wave function in quantum mechanics represents

(a) a state of the system

(b) shape of the system

(c) probability of the system

(d) energy of the system

59. The infrared and Raman spectra for BF_3 are expected to show

(a) the same number of peaks

(b) more absorption peaks in IR in comparison to Raman

(c) more absorption peaks in Raman in comparison with IR

(d) absorption peaks present in Raman are absent in IR

60. The total number of vibrational degree of freedom in H_2O_2 is

(a) 7

(b) 6

(c) 4

(d) 9

61. A radioactive isotope has a half-life of 30 minutes. A sample containing the said isotope will lose its activity almost completely (over 99%) in a period of at least

(a) 60 min

(b) 300 min

(c) 900 min

(d) 1800 min

62. Vitamin A is

(a) ascorbic acid

(b) retinol

(c) calciferol

(d) thiamine

63. Which of the following is steroid hormone?

(a) Progesterone

(b) Insulin

(c) Thyroxine

(d) Oxytocin

64. Monomer of natural rubber is

(a) neoprene

(b) isoprene

(c) Terylene

(d) Orlon

65. The number of atoms contained in 4 gm of oxygen is

(a) $1 \cdot 5 \times 10^{23}$

(b) 3×10^{23}

(c) $6 \cdot 2 \times 10^{19}$

(d) $6 \cdot 2 \times 10^{5}$

66. "No two electrons in an atom can have same values for the four quantum numbers" is

   (a) Hund's rule

   (b) Pauli's exclusion principle

   (c) Aufbau principle

   (d) Heisenberg uncertainty principle

67. The Schrödinger wave function ψ represents

   (a) probability density

   (b) probability amplitude

   (c) probability of particle distribution

   (d) radial probability

68. The correct order of increasing energy of atomic orbital is

   (a) $5p < 4f < 6s < 5d$

   (b) $4f < 5p < 5d < 6s$

   (c) $5p < 6s < 4f < 5d$

   (d) $5p < 5d < 4f < 6s$

69. The contribution of Max Born in the field of quantum mechanics is related to

   (a) finding the wave function of any system

   (b) finding the energy level of electrons

   (c) interpretation of wave function in terms of location of particles

   (d) finding the azimuthal quantum number value

70. Which of the following sets of ions represents the collection of isoelectronic species?

   (a) K^+, Cl^-, Mg^{2+}, Sc^{3+}

   (b) Na^+, Ca^{2+}, Sc^{3+}, F^-

   (c) K^+, Ca^{2+}, Sc^{3+}, Cl^-

   (d) Na^+, Mg^{2+}, Al^{3+}, Cl^-

71. In a double interference arrangement, one of the slits is covered by a thin mica sheet whose refractive index is 1·58. The distances of two secondary slits and slit-screen distance are 0·1 cm and 50 cm respectively. Due to introduction of mica sheet the central fringe gets shifted by 0·2 cm. The thickness of the mica sheet is

   (a)   1 cm

   (b) $6 \cdot 7 \times 10^{-4}$ cm

   (c) $0 \cdot 14$ cm

   (d) 10^4 cm

72. In a single slit of width b has diffraction pattern when a plane-wave wavelength λ passes through it. If $\beta = \dfrac{\pi b \sin \theta}{\lambda}$, then the intensity distribution is given by

   (a) $I = I_0 \dfrac{\sin \beta}{\beta}$

   (b) $I = I_0 \dfrac{1}{\beta^2}$

   (c) $I = I_0 \dfrac{\sin^2 \beta}{\beta^2}$

   (d) $I = I_0 \dfrac{\beta}{\sin \beta}$

73. When a perfect polarizer is placed in a polarized beam of light with initial intensity I_0, Malus' law says that, intensity is given by

   (a) $I_0 \sin^2 \theta$

   (b) $I_0 \cos^2 \theta$

   (c) $I_0 \sin \theta$

   (d) $I_0 \cos \theta$

   (θ is the angle between light's initial polarization direction and axis of polarizer)

74. The relation between entropy S and number of accessible states to a system Ω is given by

(a) $S = \ln(\Omega / k)$

(b) $S = k \ln(\Omega)$

(c) $S = k(\Omega)$

(d) $S = \Omega \ln(k)$

where k is Boltzmann constant.

75. The possible orientation of total angular momentum J for $j = 3/2$ and $j = 1/2$ states that corresponds to $l = 1$ is

(a) $m_j = -3/2, -1/2, 0, 1/2, 3/2$ and $m_j = -1/2, 0, 1/2$

(b) $m_j = -3/2, -1/2, 1/2, 3/2$ and $m_j = -1/2, 1/2$

(c) $m_j = -3/2, -1/2, 0, 1/2, 3/2$ and $m_j = -1/2, 1/2$

(d) $m_j = -3/2, -1/2, 1/2, 3/2$ and $m_j = -1/2, 0, 1/2$

76. The drift velocity of the free electrons in a copper wire whose cross-sectional area is 1 sq. millimetre when the wire carries 1 ampere current (electron density of copper is $8 \cdot 5 \times 10^{28}$ electrons/m^3) is

(a) $7 \cdot 4 \times 10^{-4}$ m/s

(b) 1×10^{-3} m/s

(c) $1 \cdot 4$ m/s

(d) $10 \cdot 5$ m/s

77. A uniform conducting wire of length L and circular cross-section with radius r has a resistance R. If the length of the wire is reduced by $1/4$ and radius of the wire is also reduced by half, the resistance of the new wire is

(a) $\dfrac{1}{2}R$

(b) R

(c) $2R$

(d) $4R$

78. An electron collides with a hydrogen atom in its ground state and excites it to a state $n = 3$. The amount of energy given to the hydrogen atom in this elastic collision is

(a) $12 \cdot 1$ eV

(b) $20 \cdot 3$ eV

(c) $0 \cdot 12$ eV

(d) 100 eV

79. The crystals of inert gas atoms are bound by

(a) ionic bond

(b) covalent bond

(c) hydrogen bond

(d) van der Waals interaction

80. The first Brillouin zone of a crystal lattice is

   (a) interplanar separation

   (b) ionic crystal

   (c) Wigner-Seitz primitive cell of reciprocal lattice

   (d) band structure

81. Quantum unit of crystal vibration is

   (a) photon

   (b) phonon

   (c) baryon

   (d) meson

82. Consider a crystal structure of N primitive cells. The number of orbitals in each energy band is

   (a) N

   (b) $2N$

   (c) $3N$

   (d) $4N$

83. In planetary motion, if T and R are time period and major axis of the trajectory, Kepler's law states that

(a) $T \propto R^3$

(b) $T^2 \propto R$

(c) $T^2 \propto R^3$

(d) $T^2 \propto R^2$

84. A doped semiconductor has 10 billion silicon atoms and 20 million pentavalent atoms. If the ambient temperature is 25 °C, the numbers of free electrons and holes inside the semiconductor are

(a) 10 billion free electrons and 20 million holes

(b) 0 free electrons and 20 million holes

(c) 10 billion free electrons and 0 holes

(d) 20 million free electrons and 0 holes

85. When the reverse voltage decreases from 10 V to 5 V, the depletion layer of the semiconductor

(a) becomes smaller

(b) becomes larger

(c) is unaffected

(d) breaks down

86. The knee voltage of a diode is approximately equal to

   (a) applied voltage

   (b) barrier potential

   (c) breakdown potential

   (d) forward voltage

87. A transistor acts like a diode and a

   (a) voltage source

   (b) current source

   (c) resistance

   (d) power supply

88. In an amplifier, the feedback resistor

   (a) stabilizes voltage gain

   (b) increases distortion

   (c) increases collector resistance

   (d) decreases input resistance

89. The phase-shift oscillator usually has

  (a) two lead or lag circuits

  (b) three lead or lag circuits

  (c) a lead-lag circuit

  (d) a twin T filter

90. The ratio of nuclear radius of $^{12}_{6}C$ to the nuclear radius $^{107}_{47}Ag$ is

  (a) 0·482

  (b) 1

  (c) 0·504

  (d) 0·112

91. The binding energy of neon isotope $^{20}_{10}Ne$ is 160·647. The atomic mass of the isotope is

  (a) 19·992 a.m.u.

  (b) 18·999 a.m.u.

  (c) 18·552 a.m.u.

  (d) 19·102 a.m.u.

92. Isobars are nuclides that have the same

    (a) atomic number

    (b) mass number

    (c) binding energy

    (d) decay constant

93. The SI unit of activity of radioactive nuclide is

    (a) rutherford (rd)

    (b) becquerel (Bq)

    (c) gray (Gy)

    (d) tesla (T)

94. The X-rays of wavelength 0·140 nm are reflected from a certain crystal and first order maximum occurs at an angle of 30°. The value of the interplanar spacing of this crystal is

    (a) 0·280 nm

    (b) 0·140 nm

    (c) 0·226 nm

    (d) 1 nm

95. A plane intercepts the a, b and c axes at $3a$, $2b$ and $2c$ respectively. The Miller indices of the plane are

    (a) (3,2,2)

    (b) (2,3,3)

    (c) (2,3,2)

    (d) (2,2,3)

Section—D

(Mathematics)

(Table for Standard Normal Distribution is provided)

96. Suppose that an archeologist excavates a bone and measures its content of radioactive carbon $_6C^{14}$. Half-life of $_6C^{14}$ is given as 5730 years. If the result is 25% of the content in bones of a living organism, the age of the bone is

(a) 15530 years

(b) 500 years

(c) 11460 years

(d) 8500 years

97. The solution to the initial-value problem $y'' + y' - 2y = 0$, $y(0) = 4$ and $y'(0) = -5$ is

(a) $y = e^x + 3e^{-2x}$

(b) $y = e^{-x} + 2e^{-2x}$

(c) $y = e^{2x} + 3e^x$

(d) $y = 3e^{-\pi x}$

98. The dimensions of the null space and column space of the matrix

$$A = \begin{bmatrix} -3 & 6 & -1 & 1 & -7 \\ 1 & -2 & 2 & 3 & -1 \\ 2 & -4 & 5 & 8 & -4 \end{bmatrix}$$

are

(a) 0, 5

(b) 1, 4

(c) 5, 0

(d) 3, 2

99. In a given population, the overall risk of developing cancer is about 0·1%. Among the 20% of the population who are smokers, the risk is about 0·4%. The probability of a non-smoker developing lung cancer is

(a) 0·00025

(b) 0·04

(c) 0·2

(d) 0·0001

100. Given a vector field $\mathbf{F} = \left(yze^{xy}, xze^{xy}, e^{xy} + 3\cos 3z \right)$. The divergence of the vector field $\mathbf{F}$ is

(a) div $\mathbf{F} = y^2ze^{xy} + x^2ze^{xy} - 9\sin 3z$

(b) div $\mathbf{F} = ze^{xy} + y^2ze^{xy} - \cos z$

(c) div $\mathbf{F} = y^2z + x^2ze^y - \cos 3z$

(d) div $\mathbf{F} = e^{xy} + x^2ze^y - \tan 3z$

101. Given a vector field $\mathbf{F} = \left(yz^2 + xy + yz \right)$. div (curl $\mathbf{F}$) is given as

(a)   −1

(b)   2

(c)   3

(d)   0

102. A type II error is made when

(a)   the null hypothesis is accepted when it is false

(b)   the null hypothesis is rejected when it is true

(c)   the alternate hypothesis is accepted when it is false

(d)   the null hypothesis is accepted when it is true

103. In a two-tailed hypothesis about a population mean with a sample size of 100 and $\alpha = 0 \cdot 05$, the rejection region would be

(a) $z > 1 \cdot 64$

(b) $z > 1 \cdot 96$

(c) $z < -1 \cdot 64$ and $z > 1 \cdot 64$

(d) $z < -1 \cdot 96$ and $z > 1 \cdot 96$

104. The second Taylor polynomial for $f(t, y) = \sqrt{4t + 12y - t^2 - 2y^2 - 6}$ about (2, 3) is

(a) $P_2(t, y) = 4 - \dfrac{1}{4}(t - 2)^2 - \dfrac{1}{2}(y - 3)^2$

(b) $P_2(t, y) = 4 - \dfrac{1}{2}(t - 2)^2 - \dfrac{1}{4}(y - 3)^2$

(c) $P_2(t, y) = 4 - \dfrac{1}{4}(t - 2)^3 - \dfrac{1}{2}(y - 3)^2$

(d) $P_2(t, y) = 4 - (t - 2)^2 - \dfrac{1}{2}(y - 3)^2$

105. The solution to the initial-value problem $y'' + \omega^2 y = 0$, given $y(0) = A$, $y'(0) = B$ is

(a) $y = \cos \omega t + \dfrac{B}{\omega} \sin \omega t$

(b) $y = B\cos \omega t + \dfrac{B}{\omega} \sin \omega t$

(c) $y = A\cos t + \dfrac{B}{\omega} \sin \omega t$

(d) $y = A\cos \omega t + \dfrac{B}{\omega} \sin \omega t$

106. The residues at the singular points of the function $f(z) = \dfrac{z}{(z+1)(z-2)}$ are

(a) $1/2$ and $1/3$

(b) $1/3$ and $2/3$

(c) $1/4$ and $1/3$

(d) $2/5$

107. The value of the integration $I = \int_0^\infty a^{-bx^2} dx$ is

(a) $\dfrac{\sqrt{\pi}}{a\sqrt{b}}$

(b) $\dfrac{\sqrt{\pi}}{\sqrt{b/a}}$

(c) $\dfrac{\sqrt{\pi}}{\sqrt{2b\ln(a)}}$

(d) $\dfrac{\sqrt{\pi}}{\sqrt{a\ln(b)}}$

108. Three machines A, B and C produce respectively 50%, 30% and 20% of the total number of items of a factory. The percentage of defective output of these machines are 3%, 4% and 5%. If an item is selected at random, the probability that the item is defective, is

(a) 1

(b) 0

(c) 0·18

(d) 0·037

/89-A   28

109. If $G = (V, E)$ is an undirected graph or multigraph, then $\sum_{v \in V} \text{degree}(v)$ is

(a) $|E|$

(b) $2|E|$

(c) $3|E|$

(d) $3|V|$

110. The general solution of the differential equation $\dfrac{d^2 y}{dx^2} + 2\dfrac{dy}{dx} + y = 2e^{3x}$ is

(a) $y = (C_1 + C_2 x)e^{-x}$

(b) $y = C_1 e^{-x} + e^{3x}$

(c) $y = (C_1 + C_2 x)e^{-x} + \dfrac{e^{3x}}{8}$

(d) $y = \dfrac{e^{3x}}{8}$

111. Consider $g(x)$ be continuous and $\dfrac{dg(x)}{dx}$ integrable one-dimensional function on x-axis and $g(x) \to 0$ as $|x| \to \infty$. If Fourier transform of $g(x)$ is given by $G(k)$, then Fourier transform of $\dfrac{d^2 g(x)}{dx^2}$ is given by

(a) $kG(k)$

(b) $k^2 G(k)$

(c) $-kG(k)$

(d) $-k^2 G(k)$

112. If z is a complex variable, then $\oint_C \dfrac{dz}{z}$, where C represents unit circle, is given by

(a) 2π

(b) $2\pi i$

(c) π

(d) πi

113. Consider a particle constrained to move along a straight string connecting two points (1, 2) and (4, 6). Now the string makes a circular path by connecting the two ends so that the particle can move continuously along it. The area of the circle made by the string is

(a) $2/\pi$

(b) $25/(4\pi)$

(c) 5π

(d) $\pi/25$

114. The Laplace transform of the following piecewise continuous function

$$f(t) = 0, \quad 0 \le t < 2$$
$$k, \quad t \ge 2, \quad k \text{ is a constant}$$

is

(a) k

(b) $\dfrac{ke^{-2s}}{s}$

(c) $\dfrac{k}{s}$

(d) $\dfrac{ke^{-s}}{2s}$

115. The altitude of a right circular cone is 15 cm and is increasing at 0·2 cm/sec. The radius of the base is 10 cm and is decreasing at 0·3 cm/sec. How fast the volume is changing?

(a) Decreasing at the rate $\dfrac{70\pi}{3}$

(b) Increasing at the rate $\dfrac{70\pi}{3}$

(c) Remains constant at 20π

(d) 0

116. The series $\displaystyle\sum_{n=0}^{\infty} \dfrac{(100 + 75i)^n}{n!}$ is

(a) convergent

(b) divergent

(c) neither convergent nor divergent

(d) None of the above

117. For what value of b is the line $y = 10x$ tangent to the curve $y = e^{bx}$ at some point in the xy-plane?

(a) $\dfrac{10}{e}$

(b) 10

(c) $10e$

(d) e^{10}

118. Let M be a 5×5 real matrix. Exactly four of the following five conditions on M are equivalent to each other. Which of the five conditions is equivalent to *none* of the other four?

(a) For any two distinct column vectors $\mathbf{u}$ and $\mathbf{v}$ of M, the set $\{\mathbf{u}, \mathbf{v}\}$ is linearly independent

(b) The homogeneous system $M\mathbf{x} = \mathbf{0}$ has only the trivial solution

(c) The system of equations $M\mathbf{x} = \mathbf{b}$ has a unique solution for each real 5×1 column vector $\mathbf{b}$

(d) The determinant of M is nonzero

119. Let K be a nonempty subset of $\mathbb{R}^n$, where $n > 1$. Which of the following statements must be true?

I. If K is compact, then every continuous real-valued function defined on K is bounded.

II. If every continuous real-valued function defined on K is bounded, then K is compact.

III. If K is compact, then K is connected.

(a) I only

(b) II only

(c) III only

(d) I and II only

120. If f is the function defined by
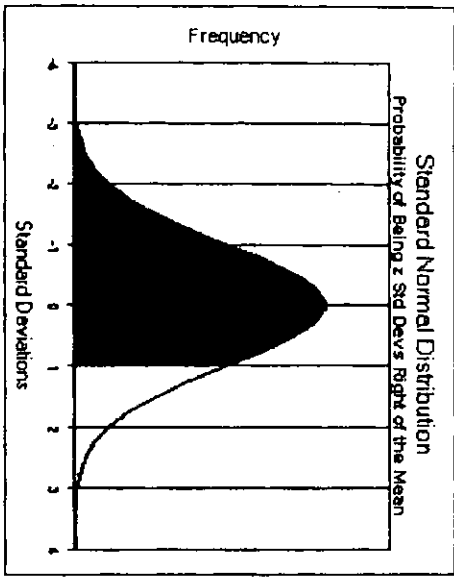
$$f(x) = \begin{cases} xe^{-x^2 - x^{-2}} & , \text{ if } x \neq 0 \\ 0 & , \text{ if } x = 0 \end{cases}$$

at how many values of x does the graph of f have a horizontal tangent line?

(a) None

(b) One

(c) Two

(d) Three

The Cumulative Standard Normal Distribution

$$F_X(x) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} e^{-\frac{z^2}{2}} dz$$

Standard Normal Distribution
Probability of Being z Std Devs Right of the Mean

Frequency / Standard Deviations

Cumulative Probabilities of the Standard Normal Distribution *

z is the number of standard deviations to the right of the center of the distribution.

z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990

*The probability that the mean of a sample, X will be between four standard deviations left of the mean and z standard deviations right of the mean. (The population mean is at the center of the distribution and the probability of the mean of a sample being between the center of the distribution and four standard deviations left of the center is 0.5000.) The probability represented by the colored area in the chart above is 0.8413, which corresponds with one standard deviation right of the mean.

Section—E

(Bioinformatics)

121. The peptide bond is planar due to

(a) restriction caused by rotation around C_α—N bond

(b) restriction around C_α—N bond

(c) extended delocalization of the lone pair of electrons of the nitrogen onto carbonyl oxygen

(d) hydrogen bonding between amide protons and carbonyl oxygen

122. In a molecular dynamics simulation, Gibbs free energy is the appropriate quantiy if the system has

(a) constant number of particles, energy and volume

(b) constant number of particles, temperature and volume

(c) constant number of particles, temperature and pressure

(d) constant chemical potential, temperature and volume

123. Which of the following statements is correct?

(a) Smith-Waterman algorithm is used to perform global sequence alignment

(b) Needleman-Wunsch algorithm is used to perform local sequence alignment

(c) In Smith-Waterman algorithm, the negative scoring cells of the matrix is set to 0

(d) Needleman-Wunsch algorithm performs word matches

124. The number of genes identified in the human genome is about approximately 30000 whereas the total number of proteins produced in the different tissues of a man are estimated to be about four times as many, namely about 120000. This happens, because

(a) the structure of a gene is variable, depending on the nature of the tissue

(b) there is translational frame shifting

(c) there can be alternate splicing

(d) of extensive recombination

125. In synthetic mRNA composed of 3/4 uracil and 1/4 guanine, the expected frequencies of the triplets UGC and GUG are in the ratio

(a) 1 : 1

(b) 3 : 1

(c) 9 : 1

(d) 27 : 1

126. Two protein sequences are compared by BLAST and produce an E value of e^{-100}. This E value most likely signifies which of the following about the genes encoding these two proteins?

(a) They function in the same tissue

(b) They have unrelated functions

(c) They are descended from a common ancestor

(d) They are derived from related species

127. Assuming uniform substitution rates among nucleotides, the scores (in bits) derived from a PAM 10 substitution matrix is—match score (1·86) and mismatch score (−3·0). What is the odd score for the ungapped alignment below?

$$A\ T\ G\ T\ C\ G$$
$$C\ T\ G\ G\ C\ G$$

(a) 1·41

(b) 2·71

(c) 4·28

(d) 1·71

128. Which of the following peptides is likely to form an amphipathic helix?

(a) phe-asp-arg-gly-leu-glu-ile-ile-lys-ser-gly

(b) arg-asp-ser-gly-phe-leu-asp-ile-gly-glu-lys

(c) phe-asp-gly-arg-leu-glu-ile-lys-ile-ser-gly

(d) phe-gly-leu-ile-asp-arg-glu-lys-ile-ser-gly

129. Which one of the following can be used as an improper dihedral term to maintain planarity of the imidazole ring of histidine in molecular dynamics simulations?

(a) CB-CG-ND1-CE2

(b) CB-CG-CD2-NE2

(c) CD2-CG-ND1-NE2

(d) CA-CB-CG-ND1

130. The amino acid sequence of a protein P1 was used to query the n.r. (non-redundant) database at NCBI using the BLAST interface. There were to hits, H1 and H2. Some of the relevant details P1-H1 and P1-H2 alignments are given below :

	Hit H1	Hit H2
Query coverage	20%	89%
Subject coverage	14%	92%
E value	$1·2 \times 10^{-132}$	$1·2 \times 10^{-32}$
Identity	79%	39%
Similarity	87%	64%

This data justifies which one of the following inferences?

(a) P1 and H1 are homologs

(b) P1 and H2 are homologs

(c) H1 and H2 are homologs

(d) P1, H1 and H2 are all homologs

131. In the context of RNA secondary structure, which one of the following motifs is *not* possible?

(a) Stem   (b) Bulge

(c) Groove   (d) Hairpin loop

132. Equivalent PAM and Blosum matrices based on relative entropy are

(a) PAM100 $\Rightarrow$ Blosum90   (b) PAM120 $\Rightarrow$ Blosum52

(c) PAM160 $\Rightarrow$ Blosum80   (d) PAM200 $\Rightarrow$ Blosum60

133. If a 20-residue peptide in occurring in three different conformational states alpha helix (A), beta strand (B) and beta hairpin (C), which of the following correspond to decreasing order of N- to C-terminus distance?

(a) B, A, C

(b) A, B, C

(c) C, A, B

(d) All three will be identical

134. In the DSSP method, assignment of secondary structures of proteins is done on the basis of

(a) main chain torsion angles

(b) empirical hydrogen bond energy calculation

(c) Coulomb hydrogen bond energy calculation

(d) matching C^α coordinates with a linear distance mask of ideal secondary structures

135. The conserved sequence motif for the family of AMP binding proteins is

    [LIVMFY]-X(2)-[STG]-[STAG]-G-[ST]-[STEI]-[SG]-X-[PASLIVM]-[KR]

    You are given sequence of a 34-amino acid stretch starting from the first residue of the motif. Which of the following proteins is likely to have AMP binding function?

    (a) LIVMFYNGSTGSTAGGSTSTEISGAPASLIVMKR

    (b) MAGTAGSEGYIRHHCSCDGSYPFDVITVNGKTYL

    (c) LIVMFYNGSTGSTAGCSTSTEISGAPASLIVMDE

    (d) LSSTAYTTSALKAAAAAAAAAAAARRRRRRRRRR

136. When the Chou-Fasman method is used to predict secondary structures in proteins, which amino acid has the highest propensity of entering into beta sheets?

    (a) Thr   (b) Val

    (c) Phe   (d) Ala

137. The region (– 60, – 60) in the Ramachandran plot refers to

    (a) loop region

    (b) beta sheet reigon

    (c) alpha helical region

    (d) No specific secondary structure

138. In the Blosum scoring matrix, the score $S(i, j)$ for match/mismatch between two amino acids is given by the formula $S(i, j) = (1/\lambda)\log(p_{ij}/(p_i * p_j))$, where λ is the scaling factor. The quantity p_i represents

    (a) the probability of seeing an amino acid i at random position

    (b) the probability of seeing an amino acid i at non-random position

    (c) the probability of seeing an amino acid i as per normal distribution

    (d) the probability of seeing an amino acid i as per Poisson distribution

139. The terms contigs and scaffolds together are associated with

    (a) genome assembly

    (b) gene prediction

    (c) gene array

    (d) gene clustering

140. Fourier transform-based methods capture —— patterns embedded in a given DNA symbolic sequence.

    (a) random   (b) periodic

    (c) word   (d) n-mer

141. EST sequences are useful in predicting

    (a) codons

    (b) exons

    (c) TF sites

    (d) poly A sites

142. —— strategy is used to evaluate the branching pattern of the phylogenetic tree is true.

    (a) Alignment

    (b) Bootstrap

    (c) Clustering

    (d) Comparison

143. In the evolutionary point of viewpoint, paralogues are due to

    (a) gene deletion

    (b) gene duplication

    (c) gene addition

    (d) gene silencing

144. If the number of distinct species considered is 4, then how many distinct unannotated trees can be generated using phylogenetic analysis?

    (a) 3

    (b) 4

    (c) 8

    (d) 5

145. Generally the 'consensus sequence pattern' is derived from multiple sequence alignment. In that context, which one of the following statements is true?

    (a) Only the dominant nucleotide in each column is considered for the consensus pattern

    (b) All the nucleotides in each column are considered for the consensus pattern

    (c) Only purines are considered for the consensus pattern

    (d) Only pyrimidines are considered for the consensus pattern

★ ★ ★