89

QUESTION PAPER
SERIES CODE

A

Registration No. :

Centre of Exam. : _____

Name of Candidate : _____

_____
Signature of Invigilator

ENTRANCE EXAMINATION, 2013
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 **six** sections of twenty-five (25) questions each. Candidates may choose any **two** sections and answer fifty (50) questions. Each question carries 1 mark and **0·25 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 correct the 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 <u>ONLY ONE CIRCLE</u> for each question as shown in example below :

Wrong	Wrong	Wrong	Wrong	Correct
● ⓑ ⓒ ●	⓪ ⓑ ⓒ ⓓ	⓪ ⓑ ⓒ ⓪	◉ ⓑ ⓒ ●	ⓐ ⓑ ⓒ ●

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.**

PART—A

Answer all questions

1. A 3·0 L solution of $BaCl_2$ has a chloride ion concentration of 0·20 M. The barium ion concentration in this solution is

   (a) 0·067 M

   (b) 0·10 M

   (c) 0·20 M

   (d) 0·60 M

2. A reducing agent

   (a) loses electrons and is reduced

   (b) gains electrons and is reduced

   (c) loses electrons and is oxidized

   (d) gains electrons and is oxidized

3. Angle strain in which compound is maximum?

   (a) Butane

   (b) Cyclobutane

   (c) Propane

   (d) Cyclopropane

4. Which of the following compounds has sp^2 hybridization?

   (a) CO_2

   (b) SO_2

   (c) NO_2

   (d) CO

5. What is the major product of the following reaction?

$$CH_3-\overset{\overset{O}{\|}}{C}-CH_2-CH_3 \xrightarrow[CH_3OH]{NaBH_4}$$
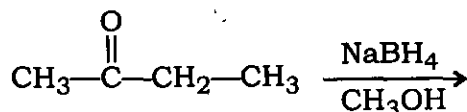
   (a) S-2-butanol

   (b) R-2-butanol

   (c) A racemic mixture of 2-butanol

   (d) The hemiketal of 2-butanone and methanol...2-hydroxy-2-methoxybutane

6. In which of the following processes convection does not take place primarily?

(a) Sea and land breeze

(b) Boiling of water

(c) Warming a glass of bulb due to filament

(d) Heating air around a furnace

7. A real gas behaves like an ideal gas if its

(a) pressure and temperature are both high

(b) pressure and temperature are both low

(c) pressure is high and temperature is low

(d) pressure is low and temperature is high

8. In the given circuit, with steady current, the potential difference across the capacitor must be

V, R R

C

$2R$

(a) V

(b) $V/2$

(c) $V/3$
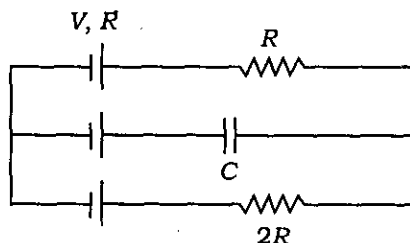
(d) $2V/3$

9. A circular loop of radius R, carrying current I, lies in x-y plane with its centre at origin. The total magnetic flux through x-y plane is

(a) directly proportional to I

(b) directly proportional to R

(c) inversely proportional to R

(d) zero

10. An infinitely long cylinder is kept parallel to a uniform magnetic field B directed along positive z-axis. The direction of induced current is seen from z-axis will be

(a) clockwise of the +ve z-axis

(b) anticlockwise of the +ve z-axis

(c) zero

(d) along the magnetic field

11. $\dfrac{d}{dt}t\sqrt{t}$ is given by

(a) $\sqrt{t}$

(b) $\dfrac{1}{2}\sqrt{t}$

(c) $\dfrac{3}{2}\sqrt{t}$

(d) $\dfrac{5}{2}\sqrt{t}$

12. Foci of an ellipse are $(3, 0)$ and $(-3, 0)$ and eccentricity is $\dfrac{1}{3}$. What is the equation of this ellipse?

(a) $\dfrac{x^2}{81}+\dfrac{y^2}{72}=1$

(b) $\dfrac{x^2}{72}+\dfrac{y^2}{81}=1$

(c) $\dfrac{x^2}{81}+\dfrac{y^2}{16}=1$

(d) $\dfrac{x^2}{16}+\dfrac{y^2}{81}=1$

13. Centre and radius of the circle $x^2+y^2+6x-4y+4=0$ are

(a) $(-3, 2)$ and 3

(b) $(-2, 3)$ and 3

(c) $(-3, 2)$ and 2

(d) $(-2, 3)$ and 2

14. If the mean of numbers 28, x, 42, 78 and 104 is 62, then what is the mean of 128, 255, 511, 1023 and x?

(a) 395

(b) 275

(c) 355

(d) 415

15. In a class, 40% of the students enrolled for Mathematics and 70% enrolled for Economics. If 15% of the students enrolled for both Mathematics and Economics, what percentage of the students of the class did not enroll for either of the two subjects?

(a) 5%

(b) 15%

(c) 0%

(d) 25%

16. What is the term for an observable trait of an organism?

(a) Element

(b) Phenotype

(c) Pleiotropy

(d) Genotype

17. Which of the following is *not* routinely used genome sequencing projects?

(a) Mammalian artificial chromosomes (MACs)

(b) Bacteriophage P1 derived (PACs)

(c) Bacterial artificial chromosomes (BACs) using the F-factor of *E. coli*

(d) Yeast artificial chromosomes (YACs)

18. Which of the following is a symbiotic nitrogen-fixing organism?

(a) Azotobacter

(b) Clostridium

(c) Rhizobium

(d) Klebsiella

19. Which of the following virus families infects plants?

(a) *Adenoviridae*

(b) *Baculoviridae*

(c) *Tobamovirus*

(d) *Herpesviridae*

20. *E. coli* belongs to

(a) archea

(b) bacteria

(c) eukaryote

(d) mammal

PART—B

Section—A

(Biology)

21. Which of the following pairs of X as sole carbon source, and Y as sole environmental electron acceptor, would it be energetically possible for bacteria to survive?

    (a) X is B-hydroxybutyrate and Y is elemental sulphur

    (b) X is acetaldehyde and Y is acetaldehyde

    (c) X is ethanol and Y is SO_4^{2-}

    (d) X is ethanol and Y is elemental sulphur

22. Which of the following phrases is most likely to complete the following statement correctly?

    Tissues that actively carry out electron transport from NADH to O_2 without coupled oxidative phosphorylation are

    (a) found in the frog but not in the water rat

    (b) found in neither rabbits nor tortoises

    (c) found in the otter but not in the crocodile

    (d) found in both whales and sharks

23. The time required for two replication forks traveling in opposite directions to traverse the entire *E. coli* chromosome at 37 °C is 40 minutes, regardless of the culture conditions. However, in a rich medium, the cells divide every 20 minutes. Which of the following statements is true for cells growing in rich medium?

    (a) Half of the daughter cells are non-viable

    (b) *E. coli* has an average of four replication forks per chromosome

    (c) *E. coli* has an average of six replication forks per chromosome

    (d) There is an altered mechanism of chain growth so that four daughter duplexes are produced simultaneously at each fork

24. Which of the following mutational changes would be the most deleterious to gene function?

    (a) Insertion of a single nucleotide near the end of the coding sequence

    (b) Insertion of a single nucleotide near the beginning of the coding sequence

    (c) Substitution of one nucleotide for another in the middle of the coding sequence

   (d) Deletion of three nucleotides in the middle of the coding sequence

25. What is cyclic about cyclic-AMP?

(a) The ribose sugar rings are fused to each other

(b) The ribose and adenine together form three rings

(c) A phosphodiester ring is formed between the phosphorus, oxygen and ribose sugar

(d) The molecule is recycled during the acyclic pathway—the Calvin cycle during photosynthesis

26. Myosin is a large protein (520 kDa) consisting of six polypeptide chains, two heavy chains (220 kDa each) and two pairs of light chains (20 kDa each). Which of the following activities of myosin is false?

(a) Myosin spontaneously assembles into filaments in solutions of physiological ionic strength and pH

(b) Myosin binds actin to form a dimer in muscle cells

(c) Myosin is an ATPase, hydrolyzing ATP to ADP and Pi

(d) Myosin binds the polymerized form of actin

27. The structure of the amino acid in the following figure is
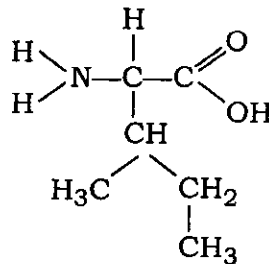
(a) leucine

(b) isoleucine

(c) valine

(d) alanine

28. Which of the following methods is *not* used in three-dimensional structure determination of proteins?

(a) Circular dichroism

(b) X-ray diffraction

(c) NMR-spectroscopy

(d) Cryoelectron microscopy

29. Edman degradation involves

(a) C-terminal residue identification using dansyl chloride

(b) phenyl isothiocyanate derivatization of the uncharged N-terminal residue

(c) fluorodinitrobenzene reagents

(d) hydrolysis with 6 M HCl

30. Which of the following enzymes is activated through a reversible covalent modification?

(a) Pepsin

(b) Chitin synthetase

(c) Plasmin

(d) Phosphofructokinase

31. For an enzyme reaction described by the Michaelis-Menten kinetics, where V_0 is the initial velocity of the reaction, S is the substrate concentration and V_{max} the maximum velocity of the enzyme (i.e., at infinite concentration of the substrate), the Lineweaver-Burke plot

(a) plots V_0 against S to determine V_{max}

(b) plots $1/V_0$ against $1/S$ to determine V_{max}

(c) plots V_0/S against V_0 to determine V_{max}

(d) plots V_0/S against V_0 to determine the reaction rate constant

32. Competitive inhibition is when an inhibitor binds reversibly to the active site of an enzyme, competing with the substrate. In addition, the term is used to describe the case when

(a) inhibitor binds reversibly to a non-enzymatic active site preventing the reaction

(b) a reduction in the apparent affinity of the enzyme

(c) there is a reduction of the maximum velocity (V_{max}) of the enzyme

(d) there is no change in the K_m (Michaelis constant) of the enzyme

33. With reference to membranes, which of the following is true?

(a) Cholesterol, sphingomyelin and glycosphingolipids in the outer leaflet of the membrane form lipid rafts

(b) Membrane proteins are amphipathic and float on the surface of the two-dimensional lipid surface in the fluid-mosaic model

(c) Cholesterol is present in microbes and animal plasma membranes but absent in plants

(d) If the degree of unsaturation in the fatty acid chains of the lipid increases, it causes the fluidity of the membrane to decrease

34. The activation of G-protein coupled receptors through the trimeric G-proteins in turn activates

(a) inositol 1,4,5-triphosphate (IP_3) pathways

(b) 1,2-diacylglycerol (DAG) pathways

(c) Ca^{2+}/calmodulin mediated pathways

(d) Ras, Rho and Rab mediated pathways

35. Which of the following statements is false about DNA replication?

(a) DNA polymerase can only generate $5' \to 3'$ daughter strands

(b) DNA synthesis takes place at a replication fork with a leading strand built continuously and a lagging strand built in short bursts called Okazaki fragments

(c) DNA helicase breaks the phosphodiester bond in one strand ahead of the replication fork allowing the DNA to rotate freely around the intact strand

(d) Topoisomerase separates interlocked circular DNA after replication

36. Which of the following is **not** a precursor for gluconeogenesis?

(a) Lactate and pyruvate

(b) Glycogen

(c) Amino acids

(d) Glycerol

37. Which of the following takes place in the dark reaction phase of photosynthesis?

(a) Plastocyanin activation by the cytochrome b_6f complex

(b) Rubisco (Ribulose biphosphate carboxylase) activity to create 3-phosphoglycerate

(c) NADP reductase transfers electrons from ferrodoxin to reduce $NADP^+$ to NADPH

(d) $P680^+$ extracts an electron from water to return to the P680

38. Which of the following statements is correct?

    (a)   Microarrays have only one probe for each gene

    (b)   Oligodendrimers are used to amplify the fluorescent signal from microarrays

    (c)   Cy3 and Cy5 dyes are used in microarrays to label the 5′ and 3′ ends of DNA respectively

    (d)   Aminoallyl coatings are used to print cDNA arrays

39. How is the distance to a food source communicated by a dancing honeybee?

    (a)   By the direction it waggles its abdomen

    (b)   The speed at which it repeats its dance

    (c)   By which direction it turns after making the straight run

    (d)   None of the above. Bees can't communicate the distance, only the direction

40. In cats, the primary gene for coat colour for the colours brown, chocolate, cinnamon, etc., can be masked by the co-dominant gene for the orange colour which is located on the chromosome and has two alleles. It is found that in female cats, a mixture of colours (called tortoise shell) is found, while in males this is not present. Which of the following is true?

    (a)   This is due to the co-dominant nature of the X-linked genes, which allows co-expression

    (b)   X-inactivation—where one chromosome is randomly switched off during development—is the cause of this trait

    (c)   Cat colour does not follow Mendelian inheritance as it is controlled by the primary gene which is multiallelic and not by the co-dominant gene

    (d)   The colour is controlled by the Y-chromosome due to X-linked nature of the alleles

41. An example of an isozyme is

    (a)   alcohol dehydrogenase from *E. coli* and *Helicobacter pylori*—examples of enzymes sourced from different organisms that perform the same function

    (b)   allosteric regulation of an enzyme causing different activities

    (c)   lactate dehydrogenase (LDH) has different forms by forming a tetramer of two different types of subunits called H and M, which have small differences in amino acid sequence

    (d)   the case of two enzymes recently diverged from a common ancestor to perform different functions

42. Which of the following basal salt solutions (BSS) is used in animal tissue culture requiring equilibration with 5% CO_2?

(a) Eagle's spinner salt solution

(b) Dulbecco's phosphate-buffered saline

(c) Hank's balanced salt solution

(d) Tris-buffered saline

43. Which of the following is *not* a mechanism known to cause apoptosis?

(a) Internal signals resulting in the complex of cytochrome c, Apaf-1, caspase 9 and ATP

(b) Cytotoxic T cells mediated

(c) DNA polymerase end-labeling of fragmented DNA

(d) Reactive oxygen species cause damage to cell

44. Which of the following organisms *does not* cause respiratory tract infections?

(a) *Entamoeba histolytica*

(b) *Haemophilus influenza*

(c) *Vibrio cholerae*

(d) *Staphylococcus aureus*

45. Which of the following immunoglobulins is rarely found in blood serum?

(a) IgG

(b) IgE

(c) IgA

(d) IgM

Section—B

(Chemistry)

46. In which of the following processes, a maximum increase in entropy is obeserved?

    (a) Dissolution of salt in water

    (b) Condensation of water

    (c) Sublimation of naphthalene

    (d) Melting of ice

47. For a particular reversible reaction at temperature T, ΔH and ΔS were found to be both +ve. If T_e is the temperature at equilibrium, the reaction would be spontaneous when

    (a) $T = T_e$

    (b) $T_e > T$

    (c) $T > T_e$

    (d) T_e is 5 times of T

48. The activation energy of a reaction at a given temperature is found to be $2 \cdot 303RT$ J mol^{-1}. The ratio of rate constant to the Arrhenius factor is

    (a) 0·1

    (b) 0·01

    (c) 0·001

    (d) 0·02

49. The $sp^3 d^2$ hybridization of central atom of a molecule would lead to

    (a) square planar geometry

    (b) tetrahedral geometry

    (c) trigonal bipyramidal geometry

    (d) octahedral geometry

50. The ozone layer forms naturally by

    (a) the interaction of CFC with oxygen

    (b) the interaction of UV radiation with oxygen

    (c) the interaction of IR radiation with oxygen

    (d) the interaction of oxygen and water vapour

51. How many chiral carbon atoms are present in 2,3,4-trichloropentane?

(a) 3

(b) 2

(c) 1

(d) 4

52. There are 20 naturally occurring amino acids. The maximum number of tripeptides that can be obtained is

(a) 7465

(b) 5360

(c) 8000

(d) 6410

53. Which one of the following conformations of cyclohexane is the least stable?

(a) Boat

(b) Half-chair

(c) Chair

(d) Twisted boat

54. Paracetamol is

(a) methyl salicylate

(b) phenyl salicylate

(c) N-acetyl p-amino phenol

(d) acetylsalicylic acid

55. The relationship from which an expression for elevation of boiling point of a solution can be derived is

(a) $\ln \dfrac{K_2}{K_1} = -\dfrac{\Delta H^\circ}{R}\left(\dfrac{1}{T_1} - \dfrac{1}{T_2}\right)$

(b) $\ln \dfrac{K_2}{K_1} = -\dfrac{\Delta G^\circ}{R}\left(\dfrac{1}{T_1} - \dfrac{1}{T_2}\right)$

(c) $\ln \dfrac{K_2}{K_1} = -\dfrac{\Delta E^\circ}{R}\left(\dfrac{1}{T_1} - \dfrac{1}{T_2}\right)$

(d) $\ln \dfrac{K_2}{K_1} = -\dfrac{\Delta S^\circ}{R}\left(\dfrac{1}{T_1} - \dfrac{1}{T_2}\right)$

56. The unit of the rate constant for a first-order reaction is

(a) s^{-1}

(b) dm^{-3} mol s^{-1}

(c) dm^{-3} $mol^{-1}s^{-1}$

(d) $dm^{-3/2}$ $mol^{1/2}s^{-1}$

57. The mean activity coefficient of $5 \cdot 0 \times 10^{-3}$ mol kg^{-1} aqueous KCl at 25 °C is given by $(A = 0 \cdot 509)$

(a) $0 \cdot 92$

(b) $0 \cdot 97$

(c) $0 \cdot 85$

(d) $0 \cdot 87$

58. The major axis of symmetry of a molecule is 6 and it has n C_2 axes perpendicular to this axis. The value of n is

(a) 1

(b) 2

(c) 3

(d) 6

59. The coordination number of a cation, in an ionic solid in which the arrangement of the anions around it is cubic, is

(a) 4

(b) 6

(c) 8

(d) 10

60. In the rotational spectra of diatomic molecules, the spacing between successive lines is equal to

(a) $\dfrac{h}{4\pi^2 Ic}$

(b) $2\left(\dfrac{h}{4\pi^2 Ic}\right)$

(c) $\dfrac{h}{4\pi^2 Ic^2}$

(d) $\dfrac{4h}{\pi^2 Ic}$

61. On the basis of the following information for the reaction

$$\frac{4}{3}Al + O_2 \rightarrow \frac{2}{3}Al_2O_3 \qquad \Delta G = -827\,kJ\,mol^{-1}$$

the minimum EMF to be applied for the electrolysis of Al_2O_3 is

(a) 8·56 V

(b) 6·42 V

(c) 4·28 V

(d) 2·14 V

62. For $6\cdot000 \times 10^{-5}\,M$ HCl, the rounded off value of pH is

(a) 4·2218488

(b) 4·2218

(c) 4·221

(d) 4·22

63. The molar masses of C_2H_6, CH_3OH and CH_3F are very similar. How do their boiling points compare?

(a) $C_2H_6 < CH_3OH < CH_3F$

(b) $CH_3F < CH_3OH < C_2H_6$

(c) $CH_3OH < CH_3F < C_2H_6$

(d) $C_2H_6 < CH_3F < CH_3OH$

64. Which of the following solutions will have pH close to 1?

(a) 100 mL of 0·1 M HCl + 100 mL of 0·1 M NaOH

(b) 75·0 mL of 0·2 M HCl + 25·0 mL of 0·1 M NaOH

(c) 55·0 mL of 0·1 M HCl + 45·0 mL of 0·1 M NaOH

(d) 10·0 mL of 0·1 M HCl + 90·0 mL of 0·1 M NaOH

65. The rate of a reaction is found to decrease with increase in temperature. Which of the following inferences can be made from this observation?

(a) Arrhenius equation is wrong

(b) The reaction comprises multiple steps

(c) The reaction is of zero order

(d) There is an error in measurement

66. If the two CH_2 planes in ethylene are perpendicular to each other, what is the point group of the molecule?

    (a) C2v

    (b) C2h

    (c) D2d

    (d) D2h

67. The migration of the colloidal particles under the influence of an electric field is known as

    (a) electrophoresis

    (b) electroosmosis

    (c) electrodialysis

    (d) electrodispersion

68. The quantum number of the Bohr orbit in a hydrogen atom whose radius is 0·01 millimetre is (given the Bohr radius of hydrogen atom is $5·292 \times 10^{-11}$ metre)

    (a) 5

    (b) 189225

    (c) 435

    (d) Cannot be calculated

69. In thermodynamics, the process is called reversible when

    (a) surroundings and system change into each other

    (b) there is no boundary between system and surroundings

    (c) surroundings are always in equilibrium with system

    (d) the system changes into the surroundings spontaneously

70. According to kinetic theory of gases, the root-mean-square velocity is

    (a) proportional to the temperature

    (b) proportional to the square of temperature

    (c) proportional to the square root of the temperature

   (d) inversely proportional to the square root of the temperature

Section—C

(Physics)

71. A particle is in an infinite square well potential with walls at $x = 0$ and $x = L$. If the particle is in the state

$$\psi(x) = A\sin\left(\frac{3\pi x}{L}\right)$$

where A is a constant, what is the probability that the particle is between $x = \frac{1}{3}L$ and $x = \frac{2}{3}L$?

(a) 0

(b) $\frac{1}{3}$

(c) $\frac{1}{\sqrt{3}}$

(d) $\frac{2}{3}$

72. Which of the following are the eigenvalues of the Hermitian matrix $\begin{pmatrix} 2 & i \\ -i & 2 \end{pmatrix}$?

(a) 1, 0

(b) 1, 3

(c) 2, 2

(d) $i, -i$

73. A rod of length L and mass M is placed along the x-axis with one end at the origin, as shown in the figure below. The rod has linear mass density $\lambda = \frac{2M}{L^2} x$, where x is the distance from the origin. Which of the following gives the x-coordinate of the rod's centre of mass?
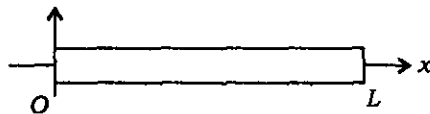
(a) $\frac{1}{12}L$

(b) $\frac{1}{4}L$

(c) $\frac{1}{3}L$

(d) $\frac{2}{3}L$

74.
$$\sigma_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}, \ \sigma_y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}, \ \sigma_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}, \ I = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

Consider the Pauli spin matrices σ_x, σ_y and σ_z and the identity matrix I given above. The commutator $[\sigma_x, \sigma_y] \equiv \sigma_x\sigma_y - \sigma_y\sigma_x$ is equal to which of the following?

(a) I

(b) $2i\sigma_x$

(c) $2i\sigma_y$

(d) $2i\sigma_z$

75. A spin $-\dfrac{1}{2}$ particle is in a state described by the spinor

$$\chi = A\begin{pmatrix} 1+i \\ 2 \end{pmatrix}$$

where A is a normalization constant. The probability of finding the particle with spin projection $S_z = -\dfrac{1}{2}\hbar$ is

(a) $\dfrac{1}{6}$

(b) $\dfrac{1}{3}$

(c) $\dfrac{1}{2}$

(d) $\dfrac{2}{3}$

76. In static electromagnetism, let E, B, J and ρ be the electric field, magnetic field, current density and charge density, respectively. Which of the following conditions allows the electric field to be written in the form $E = -\nabla\phi$, where ϕ is the electrostatic potential?

(a) $\nabla \cdot J = 0$

(b) $\nabla \cdot E = \dfrac{\rho}{\varepsilon_0}$

(c) $\nabla \times E = 0$

(d) $\nabla \times B = \mu_0 J$

77. Which of the following is described by Bose-Einstein statistics?

(a) The blackbody radiation spectrum

(b) Free-electron theory

(c) Pauli exclusion

(d) White dwarf stars

78. An observer O at rest midway between two sources of light at $x = 0$ and $x = 10\,\mathrm{m}$ observes the two sources to flash simultaneously. According to a second observer O', moving at a constant speed parallel to the x-axis, one source of light flashes 13 ns before the other. Which of the following gives the speed of O' relative to O?

(a) $0\cdot13c$

(b) $0\cdot15c$

(c) $0\cdot36c$

(d) $0\cdot53c$

79. Let $\hat{J}$ be a quantum mechanical angular momentum operator. The commutator $[\hat{J}_x, \hat{J}_y, \hat{J}_z]$ is equivalent to which of the following?

(a) 0

(b) $i\hbar\hat{J}_z$

(c) $i\hbar\hat{J}_z\hat{J}_x$

(d) $-i\hbar\hat{J}_x\hat{J}_z$

80. In the Compton effect, a photon with energy E scatters through a 90° angle from a stationary electron of mass m. The energy of the scattered photon is

(a) E

(b) $\dfrac{E}{2}$

(c) $\dfrac{E^2}{mc^2}$

(d) $\dfrac{E \cdot mc^2}{E + mc^2}$

81. A body executes simple harmonic motion with an amplitude a. The displacement of the body when its potential energy is one-third of its kinetic energy, is

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

(b) $\dfrac{a}{2}$

(c) $\dfrac{a}{\sqrt{2}}$

(d) $\dfrac{a}{\sqrt{3}}$

82. The relation among Young's modulus (Y), bulk modulus (K) and modulus of elasticity (η) is

(a) $\dfrac{3}{Y} = \dfrac{1}{K} + \dfrac{3}{\eta}$

(b) $\dfrac{3}{Y} = \dfrac{1}{\eta} + \dfrac{1}{3K}$

(c) $\dfrac{1}{Y} = \dfrac{3}{\eta} + \dfrac{1}{3K}$

(d) $\dfrac{1}{\eta} = \dfrac{3}{Y} + \dfrac{1}{3K}$

83. A long coaxial conductor carries a current I (current flows down the surface of the cylinder of radius a and back along outer cylinder of radius b). The magnetic field energy stored in a section of length I is given by

(a) $\dfrac{\mu_0 I^2 l}{4\pi} \ln\left(\dfrac{b}{a}\right)$

(b) $\dfrac{\mu_0 Il}{4\pi} \ln\left(\dfrac{b}{a}\right)$

(c) $\dfrac{\mu_0 I^2 l}{4\pi} \ln\left(\dfrac{a}{b}\right)$

(d) $\dfrac{\mu_0 Il}{4\pi} \ln\left(\dfrac{a}{b}\right)$

84. The gauge transformation in A and V for any scalar function λ, where $B = \nabla \times A$ and $E + \dfrac{\partial A}{\partial t} = -\nabla V$, is given by

(a) $A' = A - \nabla\lambda, \quad V' = V - \dfrac{\partial \lambda}{\partial t}$

(b) $A' = A + \nabla\lambda, \quad V' = V - \dfrac{\partial \lambda}{\partial t}$

(c) $A' = A - \nabla\lambda, \quad V' = V + \dfrac{\partial \lambda}{\partial t}$

(d) $A' = A + \nabla\lambda, \quad V' = V + \dfrac{\partial \lambda}{\partial t}$

85. The electric field produced by a uniformly polarized sphere of radius R at a distance $r \geq R$, with dipole moment per unit volume is P and θ is the angle between z-axis and R, is given by

(a) $V = \dfrac{P}{\varepsilon_0} \dfrac{R^3}{r^2} \cos\theta$

(b) $V = \dfrac{P}{3\varepsilon_0} \dfrac{R^3}{r^2} \cos\theta$

(c) $V = \dfrac{P}{3} \dfrac{R^3}{r^2} \sin\theta$

(d) $V = \dfrac{P}{3\varepsilon_0} \dfrac{R^3}{r^2} \sin\theta$

86. Binding energy of neon isotope $^{20}_{10}$ Ne is 160·647 MeV. The atomic mass of isotope is

(a) 19·992 a.m.u.

(b) 199·92 a.m.u.

(c) 1999·2 a.m.u.

(d) 199992 a.m.u.

87. The acceleration of a particle of mass m and velocity v when it is acted upon by a constant force F, where F is parallel to V is given by

(a) $\dfrac{F}{m}\left(1-\dfrac{v^2}{c^2}\right)^{3/2}$

(b) $\dfrac{F}{m}\left(1+\dfrac{v^2}{c^2}\right)^{3/2}$

(c) $\dfrac{F}{m}\left(1-\dfrac{v^2}{c^2}\right)^{-3/2}$

(d) $\dfrac{F}{m}\left(1+\dfrac{v^2}{c^2}\right)^{-3/2}$

88. The temperature is uniform, the pressure of a classical gas in a uniform gravitational field decreases with height according to barometric formula

(a) $p(z) = p(0)\exp[-mgz/kT]$

(b) $p(z) = p(0)\exp[-z]$

(c) $p(z) = p(0)\exp[z/kT]$

(d) $p(z) = p(0)\exp(z)^{-1}$

where the various symbols have their usual meaning.

89. The ensemble of Brownian particles initially concentrated at the origin 'diffuses out' as time increases. The mean square displacement $x^2(t)$ is given by

(a) $2Dt^2$

(b) $2Dt$

(c) $2Dt^{1/2}$

(d) $2Dt^{3/2}$

90. The equation describing transverse waves on a uniform string is

$$\frac{\partial^2 y}{\partial t^2} = \frac{T}{\mu}\frac{\partial^2 y}{\partial x^2}$$

If a string with linear density μ (kg/m) is attached to a tension T, waves will propagate at a speed given by

(a) $\dfrac{T}{\mu}$

(b) $\dfrac{\mu}{T}$

(c) μT

(d) $\sqrt{(T/\mu)}$

91. In the electromagnetic spectrum, X-rays correspond to one of the following wavelength range

(a) $0{\cdot}01$ cm to 100 km

(b) 8×10^{-5} cm to $0{\cdot}04$ cm

(c) $1{\cdot}4 \times 10^{-6}$ cm to 4×10^{-5} cm

(d) 10^{-9} cm to 10^{-5} cm

92. The essential point of the electromagnetic theory is the existence of

(a) displacement current

(b) state electric field

(c) time varying magnetic field

(d) None of the above

93. The r.m.s. speed of oxygen molecule at 273 K is (atomic mass of oxygen is 16·0 a.m.u.)

(a) 461 m/s

(b) 4·61 m/s

(c) 381 m/s

(d) 573 m/s

94. Which law of thermodynamics leads us to conclude that it is not possible to convert whole of heat into work continuously?

(a) Third law

(b) Second law

(c) First law

(d) Zeroth law

95. The expectation value $<x>$ of the position of a particle trapped in a box of width L with wave function $\psi = \sqrt{\frac{2}{L}} \sin\left(\frac{n\pi x}{L}\right)$ is given by

(a) L

(b) $\dfrac{L}{3}$

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

(d) $\dfrac{L^2}{5}$

Section—D

(Mathematics / Statistics)

96. Find the area of the region bounded by the portion of the curve $y = \sin x$ lying between the ordinates $x = 0$ and $x = 2$, and the x-axis.

    (a) 4

    (b) 0

    (c) 2

    (d) None of the above

97. For what value of x is $5 = |x - 1| + |x - 2| + |x - 3| + |x - 4 \cdot 5| + |x - 5 \cdot 5|$ minimum?

    (a) 2

    (b) 4

    (c) 4·2

    (d) None of the above

98. The algebraic sum of derivations of a set n values from their arithmetic mean is

    (a) n

    (b) 0

    (c) 1

    (d) None of the above

99. 12 persons are seated on 12 chairs at a round table. The probability that two specified persons are sitting next to each other is

    (a) 2/11!

    (b) 2/11

    (c) 1/11!

    (d) 1/6

100. The average salary of full-time workers in a firm was ₹ 5,200 and that of part-time workers was ₹ 4,200. The mean salary of all the workers was ₹ 5,000. The percentage of all full-time workers and part-time workers is respectively

    (a) 80, 20

    (b) 60, 40

    (c) 35, 65

    (d) Insufficient data

101. If x, y are positive real numbers such that $x^2 + y^2 = 1$, then $x + y + \dfrac{1}{xy}$ exceeds

(a) $2 + \sqrt{2}$

(b) $2 + \dfrac{1}{\sqrt{2}}$

(c) $2 + \dfrac{1}{\sqrt{3}}$

(d) $2 + \dfrac{1}{4}$

102. If all the roots of $x^4 - 8x^3 + 24x^2 + px + q = 0$ are positive roots, then find the value of p.

(a) -24

(b) 24

(c) -32

(d) -36

103. Given $xy + x + y = 23$, $yz + y + z = 31$, $zx + z + x = 47$. Find $[(x+1)(y+1)(z+1)]^2$.

(a) $(8 \times 24)^2$

(b) 32^3

(c) 24^3

(d) $(16 \times 32 \times 48)$

104. If α, β, γ are distinct real numbers, the number of real solutions to

$$\frac{(x - \alpha)(x - \beta)}{(\gamma - \alpha)(\gamma - \beta)} + \frac{(x - \beta)(x - \gamma)}{(\alpha - \beta)(\alpha - \gamma)} + \frac{(x - \gamma)(x - \alpha)}{(\beta - \gamma)(\beta - \alpha)} + 1 = 0$$

is

(a) 0

(b) 1

(c) 2

(d) 3

105. If x, y, z, w are four positive real numbers such that $(1+x)(1+y)(1+z)(1+w) \geq 16$, then $xyzw$ equals to

(a) $\dfrac{1}{16}$

(b) $\dfrac{1}{4}$

(c) $\dfrac{1}{2}$

(d) 1

106. Find

$$\lim_{n \to \infty} \left[\left(1 + \frac{1}{n}\right)^{2n} - \frac{1}{n} \right]$$

(a) e

(b) e^2

(c) 1

(d) None of the above

107. A license plate is to be made according to the following provision :

It has four characters, the first two characters can be any two letters of the English alphabet, and the last two characters can be any two decimal digits. How many different license plates can be made if we may repeat letters and digits?

(a) 60840

(b) 65000

(c) 58500

(d) 67600

108. The number 3 can be expressed as a sum of one or more positive integers in four ways; namely 3, $1+2$, $2+1$, $1+1+1$. Notice that the order of the summation is taken into account. In how many ways can any positive integer n be so expressed?

(a) 2^n

(b) 2^{n-1}

(c) $\dbinom{n}{2}$

(d) $n(n-1)$

109. $\sum_{k=0}^{n} k \binom{n}{k} p^k (1-p)^{n-k}$, $0 \le p \le 1$ equals to

(a) np

(b) $np(1-p)$

(c) n

(d) 2^{np}

110. Let the joint probability distribution function

$$f(x, y) = k(x^3 + y^3), \quad \text{if } 0 \le x \le 1, 0 \le y \le 1$$
$$= 0 \qquad\qquad , \text{ otherwise}$$

Determine k.

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

(b) 1

(c) 2

(d) $\dfrac{3}{4}$

111. A point (x, y, z) is taken at random and uniformly distributed from the unit cube

$$[0; 1] \times [0; 1] \times [0; 1]$$

Find the probability that its distance from the origin is in the interval $[1; \sqrt{2}]$.

(a) $\dfrac{\pi}{6}(2\sqrt{2} - 1)$

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

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

(d) π

112. It is known that the samples 3·1, 0·2, 1·6, 5·2 and 2·1 are from a random variable that is uniformly distributed over the unknown range (α, β). Find the maximum likelihood estimates for the parameters α and β.

(a) $\hat{\alpha} = 0, \hat{\beta} = 6\cdot2$

(b) $\hat{\alpha} = 0\cdot2, \hat{\beta} = 5\cdot1$

(c) $\hat{\alpha} = 0\cdot1, \hat{\beta} = 5\cdot2$

(d) $\hat{\alpha} = 0, \hat{\beta} = 7\cdot1$

113. If $\overline{X}$ is the mean of a random sample of size n from a normal population with mean μ and the variance σ^2, its sampling distribution is a normal distribution with the mean μ and variance

(a) $n\sigma^2$

(b) $\dfrac{\sigma^2}{\sqrt{n}}$

(c) $\dfrac{\sigma^2}{n^2}$

(d) $\dfrac{\sigma^2}{n}$

114. If $\overline{X}$ and S^2 are the mean and variance of a random sample of size n from a normal population with the mean μ and variance σ^2, then $T = \dfrac{\overline{X} - \mu}{S/\sqrt{n}}$ has the t-distribution with

(a) $n-2$

(b) $n-1$

(c) n

(d) $n+1$

degrees of freedom.

115. A symmetric die has proportion p of its faces painted white and proportion q of its faces painted black, where $q = 1 - p$. The die is rolled until the first time a white face shows up. What is the chance that this takes three of less rolls?

(a) p

(b) qp

(c) $(1 + q + q^2)p$

(d) $1 - (1 + q)p$

116. Suppose you play a game over and over again, each time with chance $1/N$ of winning the game, no matter what the results of the previous games. How many times n must you play to have better than 50% chance of at least one win in the n games?

(a) $n \log\left(1 - \dfrac{1}{N}\right) < \log\dfrac{1}{2}$

(b) $n \log\left(1 - \dfrac{1}{N}\right) > \log\dfrac{1}{2}$

(c) $n \log\left(\dfrac{1}{N}\right) > \log\dfrac{1}{2}$

(d) $n \log\left(\dfrac{1}{N}\right) < \log\dfrac{1}{2}$

117. Suppose X represents temperature in degree Celsius, Y the same temperature in degree Fahrenheit, so $Y = \dfrac{9}{5}X + 32$. How is standard deviation σ_Y is related to σ_X?

(a) $\sigma_Y = \sigma_X$

(b) $\sigma_Y = (81/25)\sigma_X$

(c) $\sigma_Y = \sigma_X + 32$

(d) $\sigma_Y = (9/5)\sigma_X$

118. $\displaystyle\sum_{k=0}^{\infty} k(k-1)e^{-\mu}\dfrac{\mu^k}{k!}$ is

(a) μ

(b) μ^2

(c) $e^{-\mu}$

(d) $e^{-\mu^2}$

119. Suppose you drive your car one mile at 20 miles per hour and a second mile at 60 miles per hour. What is your average speed for the two miles?

(a) 40 miles/hr

(b) 30 miles/hr

(c) 20 miles/hr

(d) 25 miles/hr

120. Given a bivariate distribution (X, Y). If $P[Y = 2X + 3] = 1$, the correlation coefficient of X and Y written as $P(X, Y)$ is

(a) $\frac{1}{2}$

(b) 1

(c) -1

(d) 0

Section—E

(Bioinformatics)

121. Viterbi algorithm is associated with

(a) generation of the position weight matrix

(b) the finding probable state path

(c) the hashing procedure of the blast results

(d) the generation of multiple alignment

122. Parsimony based method chooses the best tree having

(a) the maximum number of point mutations

(b) the least number of point mutations

(c) the maximum alignment score

(d) the minimum alignment score

123. Which of the following programs is able to carry out multiple structural alignment?

(a) Combinatorial Extension (CE)

(b) 3D PSSM

(c) 3D SEARCH

(d) SWISS-MODEL

124. Sequence complexity decreases with

(a) repeats

(b) random sequences

(c) equal distribution of nucleotides

(d) gene lengths

125. Which one of the following is incorrect in the context of nucleotide substitution model?

(a) Kimura model

(b) Jukes-Cantor model

(c) HKY model

(d) WKY model

32

126. Algorithm that is based on Bayesian framework involves the assumption of a/an

 (a) posterior probability distribution

 (b) prior probability distribution

 (c) Gaussian distribution

 (d) independent probability distribution

127. In systems biology, the dynamics of the signaling pathways are studied using

 (a) differential equations

 (b) log odds score

 (c) probability distributions

 (d) complex algebra

128. The term 'N50' in the area of genome assembly refers to

 (a) the largest value of N for which 50% of the base pairs in the bin is in supercontigs with length N base pairs or longer

 (b) the smallest value of N for which 50% of the base pairs in the bin is in supercontigs with length N*10 base pairs or longer

 (c) 50% of bases in the whole genome

 (d) 50% of correct bases in the whole genome

129. The calculated pI of a protein from the sequence may differ from the experimentally determined value, because

 (a) pI cannot accurately determined experimentally

 (b) pK_a of the amino acid side chains depend on the microstructural environment

 (c) pI calculation from the sequence does not take the N and C termini into account

 (d) pH is not known theoretically

130. Which search algorithm is used for docking chemicals in both the programs AUTODOCK and GOLD?

 (a) Monte Carlo simulation

 (b) Incremental construction

 (c) Genetic algorithm

 (d) Tabu search

131. Outer membrane proteins commonly have β-barrel structures. The prediction from sequence for such segments are more difficult than transmembrane helical proteins due to

(a) the presence of many charged and polar residues in membrane

(b) the number of amino acid spanning the membrane is higher

(c) the dependency of hydrophobicity on secondary structure

(d) inaccuracy in the available methods

132. Which amino acids often occur in the disallowed region of Ramachandran plot?

(a) GLY and PRO

(b) TYR and TRP

(c) CYS and MET

(d) LEU and ILE

133. Which automated ligand design methods is more likely to generate ligands that are chemically or synthetically plausible?

(a) The atom-by-atom ligand design method

(b) The fragment-addition ligand design method

(c) The pharmacore-pattern ligand design method

(d) The interaction-based ligand design method

134. Which of the following media is characterized by maximum dielectric constant?

(a) Vacuum

(b) Acetonitrile

(c) Tetrahydrofuran

(d) Water

135. The GOR method of protein secondary structure prediction applies the concept of

(a) Bayesian inference

(b) support vector machine

(c) fuzzy logic

(d) Monte Carlo simulation

136. It is possible to study the expression levels of hundreds of genes under various conditions using

 (a) restriction enzyme reactions

 (b) microarray experiments

 (c) high throughput sequencing

 (d) real-time PCR

137. The potential energies of various conformers of a molecule are known. Using this data, it is possible to calculate the fraction of each conformer using the

 (a) potential energy function

 (b) conformational energy function

 (c) minimum energy function

 (d) partition function

138. In a cDNA microarray experiment, which one of the following is the correct scanning parameter for the Cy3 or Cy5?

 (a) Cy5—excitation wavelength 635 nm; emission wavelength 670 nm

 (b) Cy5—excitation wavelength 535 nm; emission wavelength 570 nm

 (c) Cy3—excitation wavelength 532 nm; emission wavelength 670 nm

 (d) Cy3—excitation wavelength 632 nm; emission wavelength 670 nm

139. You are asked to browse the Protein Data Bank (PDB) to retrieve entries of all proteins encoded by the genes located on chromosome no. 13 of *Homo sapiens*. Which of the following would you use?

 (a) Source organism browser

 (b) SCOP browser

 (c) Biological process browser

 (d) Genome location browser

140. Which one of the following is *not* related to RNA secondary structure prediction?

 (a) Nussinov method

 (b) STRIDE

 (c) Covariance model method

 (d) Zuker method

141. Structure-Structure Alignment of Protein (SSAP) program is interfaced with which structural classification database?

(a) SCOP

(b) CATH

(c) FSSP

(d) HSSP

142. PSI-blast uses

(a) a standard substitution matrix in all steps or iterations

(b) a standard substitution matrix in the first step only

(c) more than two standard substitution matrix

(d) a substitution matrix created from the database

143. Markov model is applied to C_pG island prediction problem. Which one of the following is true for the positive training set?

(a) The transition probability of G followed by C is high

(b) The transition probability of C followed by G is low

(c) The transition probability of G followed by C is low

(d) The transition probability of C followed by G is high

144. Most of the motif finding algorithms treats the background model as

(a) independently and identically distributed

(b) dependently and uniformly distributed

(c) independently and normally distributed

(d) dependently and normally distributed

145. It is known that setting a threshold value may affect the prediction results. Assume that the score distribution of a training set follows a normal distribution with parameters μ and σ respectively. Which one of the following thresholds may yield the maximum number of predictions?

(a) μ

(b) $\mu + \sigma$

(c) $\mu - \sigma$

(d) $\mu - 2\sigma$

146. State 0 is both the starting state and accepting state.
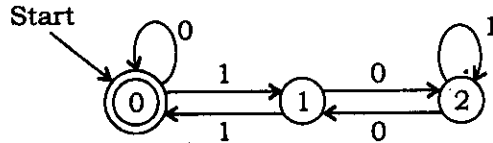
Each of the following is a regular expression that denotes a subset of the language recognized by the automaton above, *except*

(a) $0*(11)*0*$

(b) $0*1(10*1)*1$

(c) $0*1(10*1)*10*$

(d) $0*1(10*1)0(100)*$

147. An *X-Y* flip-flop operates as indicated by the following table :

Inputs		Current State	Next State
X	Y		
0	0	Q	1
0	1	Q	$\overline{Q}$
1	1	Q	0
1	0	Q	Q

Which of the following expresses the next state in terms of the *X* and *Y* inputs and the current state?

(a) $(\overline{X} \wedge \overline{Q}) \vee (\overline{Y} \wedge Q)$

(b) $(\overline{X} \wedge Q) \vee (\overline{Y} \wedge \overline{Q})$

(c) $(X \wedge \overline{Q}) \vee (Y \wedge Q)$

(d) $(X \wedge \overline{Q}) \vee (\overline{Y} \wedge Q)$

148. A black and white computer graphics display is divided up into an array of pixels as shown below :
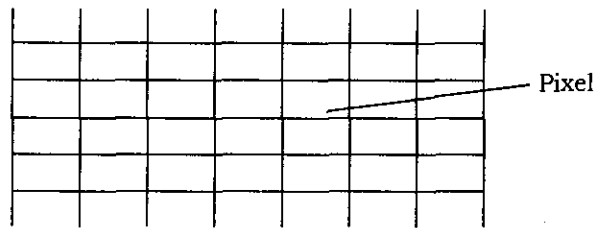
Each of the pixels can take on one of eight gray levels ranging from 0 (white) to 7 (black). In order to prevent sharp discontinuities of shade, the software system that causes pictures to be displayed enforces the rule that the gray levels of two adjacent pixels cannot differ by more than two. How many of the 64 possible assignments of gray levels to two adjacent pixels satisfy this rule?

(a) 24

(b) 32

(c) 34

(d) 40

149. A doubly linked list is declared as

Element = **record**

        value : integer;

        Fwd, Bwd : ↑ Element

  end;

where Fwd and Bwd represent forward and backward links to adjacent elements of the list.

Which of the following segments of code deletes the element pointed to by X from the doubly linked list, if it is assumed that X points to neither the first nor the last element of the list?

(a)   X↑.Bwd↑.Fwd := X↑.Fwd;

     X↑.Fwd↑.Bwd := X↑.Bwd

(b)   X↑.Bwd↑.Fwd := X↑.Bwd;

     X↑.Fwd↑.Bwd := X↑.Fwd

(c)   X↑.Bwd↑.Bwd := X↑.Fwd;

     X↑.Fwd↑.Fwd := X↑.Bwd

(d)   X↑.Bwd↑.Bwd := X↑.Bwd;

     X↑.Fwd↑.Fwd := X↑.Fwd

150. Processes *P*1 and *P*2 have a producer-consumer relationship, communicating by the use of a set of shared buffers :

> *P*1 : **repeat**
>> obtain an empty buffer
>> fill it
>> return a full buffer
>
> **forever**
>
> *P*2 : **repeat**
>> obtain a full buffer
>> empty it
>> return an empty buffer
>
> **forever**

Increasing the number of buffers is likely to do which of the following?

I.   Increase the rate at which requests are satisfied (throughput)

II. Decrease the likelihood of deadlock

III. Increase the ease of achieving a correct implementation

(a) I only

(b) II only

(c) III only

(d) II and III only

151. Which of the following sorting algorithms *does not* require external memory?

(a) Insertion sort

(b) Quicksort

(c) Bubble sort

(d) Radix sort

152. Which of the following instruction-set features is *not* generally considered an obstacle to aggression of an integer unit?

(a) Condition codes set by every instruction

(b) Variable-length encoding of instructions

(c) Instructions requiring widely varying numbers of cycles to execute

(d) Several different classes (sets) of registers

153. To compute the matrix product $M_1 M_2$, where M_1 has p rows and q columns and where M_2 has q rows and r columns, takes time proportional to pqr, and the result is a matrix of p rows and r columns. Consider the product of three matrices $N_1 N_2 N_3$ that have, respectively, w rows and x columns, x rows and y columns, and y rows and z columns. Under what condition will it take less time to compute the product as $(N_1 N_2) N_3$ (i.e., multiply the first two matrices first) than to compute it as $N_1 (N_2 N_3)$?

(a) There is no such condition, i.e., they will always take the same time

(b) $\dfrac{1}{x} + \dfrac{1}{z} < \dfrac{1}{w} + \dfrac{1}{y}$

(c) $x > y$

(d) $\dfrac{1}{w} + \dfrac{1}{x} < \dfrac{1}{y} + \dfrac{1}{z}$

154. Which of the following is usually *not* represented in a subroutine's activation record frame for a stack-based programming language?

(a) Values of local variables

(b) A heap area

(c) The return address

(d) Stack pointer for the calling activation record

155. Let A be a finite non-empty set with cardinality n. The number of subsets $S \subseteq A$ having odd cardinality is

(a) n

(b) $2^{\frac{n}{2}}$

(c) 2^{n-1}

(d) 2^n

156. A certain algorithm A has been shown to have running time $O(N^{2.5})$, where N is the size of the input. Which of the following is **not** true about algorithm A?

(a) There exist constants $C1$ and $C2$ such that for all N the running time is less than $C^1 N^{2.5} + C^2$ seconds

(b) For all N, there may be some inputs for which the running time is less than $N^{2.4}$ seconds

(c) For all N, there may be some inputs for which the running time is less than $N^{2.6}$ seconds

(d) For all N, there may be some inputs for which the running time is more than $N^{2.6}$ seconds

157. A data structure is comprised of nodes each of which has exactly two pointers to other nodes, with no null pointers. The following C program is to be used to count the number of nodes accessible from a given node. It uses a mark field, assumed to be initially zero for all nodes. There is a statement missing from this code.

```
struct test {int info, mark; struct test *p, *q;}
int nodecount (struct test *a)
{
  if (a -> mark) return 0;
  return nodecount (a ->p) + nodecount (a ->q) + 1;
}
```

Which change should be made to make the program work properly?

(a) Add "a->mark = 1;" as the first statement

(b) Add "a->mark = 1;" after the "if" statement

(c) Add "a->mark = 1;" as the last statement

(d) Add "a->mark = 0;" after the "if" statement

158. Which of the following best characterizes computers that use memory-mapped I/O?

(a) The computer provides special instructions for manipulating I/O ports

(b) I/O ports are placed at addresses on the bus and are accessed just like other memory locations

(c) To perform an I/O operation, it is sufficient to place the data in an address register and call the channel perform the operation

(d) Ports are referenced only by memory-mapped instructions of the computer and are located at memory locations

159. At lower multiprogramming levels, throughput increases as multiprogramming level increases. This is best explained by the fact that as multiprogramming level increases

(a) the system overhead increases

(b) some system resource begins to saturate (i.e., to be utilized 100%)

(c) I/O activity per request remains constant

(d) the potential for concurrent activity among system resources increases

160. At intermediate multiprogramming levels, the rate of increase of throughput with multiprogramming decreases. This phenomenon is best explained by the fact that as multiprogramming level increases

(a) I/O activity per request remains constant

(b) some system resource begins to saturate (i.e., to be utilized 100%)

(c) the utilization of memory improves

(d) the average time spent in the system by each request increases

161. If Tree 1 and Tree 2 are the trees indicated below
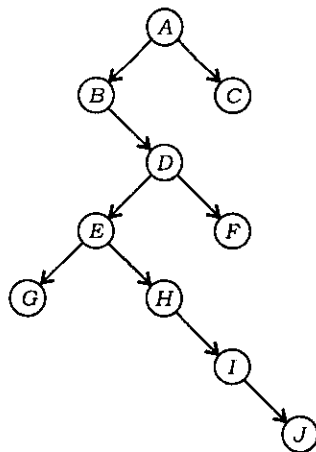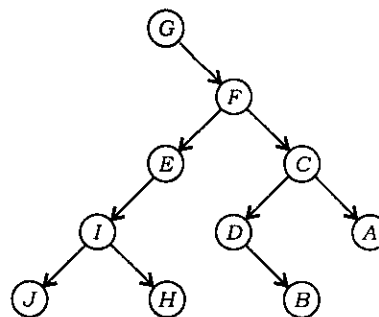
Tree 1   Tree 2

which traversals of Tree 1 and Tree 2, respectively, will produce the same sequence of node names?

(a) Preorder, postorder

(b) Postorder, inorder

(c) Postorder, postorder

(d) Inorder, inorder

162. Let A be a finite set with m elements, and let B be a finite set with n elements. The number of functions mapping A into B is

(a) n^m

(b) $n!/(n-m)!$

(c) $n!$

(d) $n!/(m!(n-m)!)$

163. $$S \to aS|b$$

The 'parsing automaton' below is for the context-free grammar with the productions indicated above :
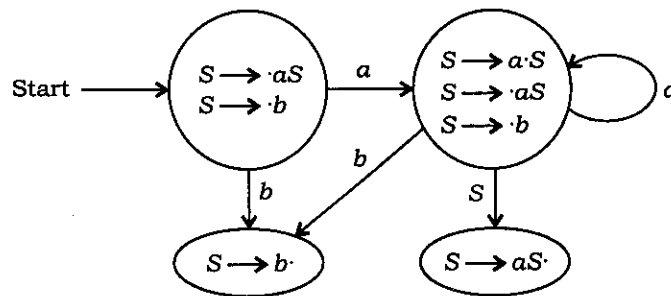

Each state includes certain 'items', which are productions with dots in their right sides. The parser automaton, with $X_1 X_2 \ldots X_n$ on the stack, reduces by production $A \to \alpha$ if and only if there labeled $X_1 X_2 \ldots X_n$ from the start state to a state that includes the item $A \to \alpha$. (Note the dot end.) Which of the following stack contents causes the parser to reduce by some production?

(a) a

(b) aa

(c) bb

(d) aaS

164. Let $k \geq 2$. Let L be the set of strings in $\{0, 1\}^*$ such that $x \in L$ if and only if the number of 0's divisible by k and the number of 1's in x is odd. The minimum number of states in a deterministic automaton (DFA) that recognizes L is

(a) $k+2$

(b) $2k$

(c) $k \log k$

(d) k^2

165. In the diagram given below, the inverter and the AND gates lebeled 1 and 2 have delays of 9, 10 and 12 nanoseconds, respectively. Wire delays are negligible. For certain values of a and c, together with a certain transition of b, a glitch (spurious output) is generated for a short time, after which the output assumes its correct value. The duration of the glitch is
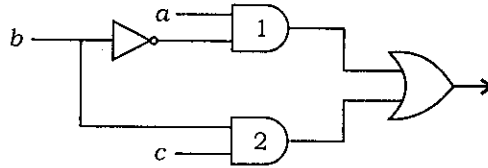
(a) 7 ns

(b) 9 ns

(c) 11 ns

(d) 13 ns

166. Which of the following sorting algorithms has a running time that is *least* dependent on the initial ordering of the input?

(a) Insertion sort

(b) Quicksort

(c) Merge sort

(d) Selection sort

167. A certain well-known computer family represents the exponents of its floating-point numbers as integers, i.e., a typical exponent $e_6e_5e_4e_3e_2e_1e_0$ represents the number $e = -64 + \sum_{i=0}^{6} 2^i e_i$. Two are input to a conventional 7-bit parallel adder. Which of the following should be accomplished in a sum that is also in excess-64 notation?

(a) The most significant adder output bit should be complemented

(b) An end-around carry should be generated

(c) The adder outputs should be bitwise complemented

(d) A low-order carry should be inserted

Questions **168** and **169** are based on the following information :

Consider a virtual memory with M resident pages and a periodic page reference string

$$p_1, p_2, ..., p_N, p_1, p_2, ..., p_N, p_1, p_2, ..., p_N$$

of N distinct requests.

Assume that the string of N requests was constructed randomly, and assume that initially none of the pages are resident.

168. Assume that $N = 2M$ and FIFO is used. If the string $p_1, p_2, ..., p_N$ is repeated three times, then page faults is
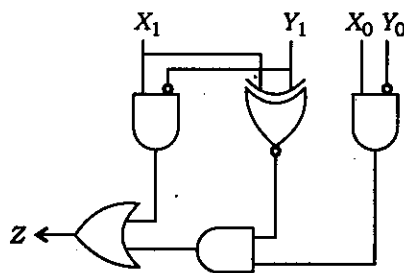
(a) $N/2$

(b) N

(c) $N + 3$

(d) $3N$

169. If the string of N requests is repeated many times, which of the following is/are true?

I. The fewest page faults occur when $M \geq N$.

II. LRU and FIFO will always result in the same number of page faults.

III. LIFO will always result in the fewest possible page faults.

(a) I only

(b) III only

(c) I and II

(d) I and III

170. The logic circuit given below is used to compare two unsigned 2-bit numbers, $X_1 X_0 = X$ and $Y_1 Y_0 = Y$ and Y_0 are the least significant bits. (A small circle on any line in a logic diagram indicates logic NOT. Which of the following always makes the output Z have the value 1?

(a) $X > Y$

(b) $X < Y$

(c) $X = Y$

(d) $X \geq Y$

★★★