

Hall Ticket No

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Time: 2 hrs**Biochemistry****Max Marks: 100**

Please read the following instructions carefully before answering:

1. Enter Hall Ticket number in the space provided above and also on OMR sheet.
2. Paper contains three sections: Part A, Part B and Part C together with 85 questions for 100 marks. **Part A contains 25 questions, each question carries one mark. Part B contains 45 questions, each question carries one mark. Part C contains 15 questions, each question carries two marks.**
3. **Part A will be used for tie breaking.**
4. **In Part A there is negative marking. 0.33 marks will be deducted for each wrong answer. In Part B there is no negative marking. In Part C there is negative marking. 0.66 marks will be deducted for each wrong answer.**
5. Answers have to be marked on the OMR sheet as per the instructions provided.
6. Apart from OMR sheet, the question paper contains 19 (Nineteen) pages including the instructions.
7. **Please return the OMR answer sheet at the end of examination.**
8. No additional sheet will be provided.
9. Rough work can be carried out in the question paper itself in the space provided at the end of the booklet.
10. Non programmable calculators are allowed.

PART A

[Each question has only one right answer. Mark the right answer. Each question carries one mark. There is negative marking. 0.33 marks will be deducted for each wrong answer]

1. Hematopoietic stem cells are found in:

- A) Lymphoid organs
- B) Skin
- C) Bone marrow
- D) Spleen

2. Temperature-sensitive mutants are important in molecular biology because they help in studying:

- A) genes for heat stress
- B) genes for cold stress
- C) genes necessary for survival of cell or organism
- D) genes involved in heat shock response

3. A block of ice in a metal container is compressed till it melts. The process is_____.

- A) Adiabatic
- B) Isothermal
- C) Isentropic
- D) Isochoric

4. Given that the density of ice = 0.9166 gm/cc, the floating volume of a block of ice, having volume V, in normal water is_____.

- A) V/2
- B) V/6
- C) V/12
- D) V/24

5. How does the wavelength of maximum intensity in the blackbody spectrum vary with absolute temperature of the blackbody?

- A) T
- B) 1/T
- C) 1/T²
- D) T³

6. What should be the molar heat capacity of an ideal gas having six degrees of freedom, according to equi-partition law

- A) 3R
- B) 6k
- C) 6T
- D) 3k

7. When water is heated isobarically at normal pressure starting from 0°C, its change of volume with temperature is

- A) Linear – increases with increase in T.
- B) Linear – decreases with increase in T.
- C) Non linear - with a minimum volume at 4°K.
- D) Non linear - with a minimum volume at 4°C

8. Which of the following compounds has the highest boiling point?

- A) CH₃CH₂CH₂CH₃
- B) CH₃NH₂
- C) CH₃OH
- D) CH₂F₂

9. Which of the following compounds is the strongest Bronsted base?

- A) CH₄
- B) NH₃
- C) H₂O
- D) HF

10. Which of the following molecules can have both *cis* and *trans* geometrical isomers?

- A) CH₃(CH₂)₂CH₃
- B) CH₂CHCH₂CH₃
- C) CH₃CCCH₃
- D) CH₃CHCHCH₃

11. Which of the following is a characteristic of methanoic acid (HCOOH) that makes it a suitable component of buffer?

- A) It changes its color when it undergoes ionization.
- B) Its ionization is incomplete.
- C) It has two ionizable hydrogens.
- D) It can ionize to produce both hydrogen and hydroxide ions.

12. Which of the following quantities contains the greatest number of moles?

- A) 30 g N₂
- B) 35 g NH₃
- C) 60 g NaCl
- D) 75 g CaO

13. In the reaction ${}_4\text{Be}^9 + \text{X} \rightarrow {}_6\text{C}^{12} + {}_0\text{n}^1$, the X represents

- A) an alpha particle
- B) a beta particle
- C) an electron
- D) a proton

14. Which statement describes characteristics of an endothermic reaction?

- A) The sign of H is *positive*, and the products have *less* potential energy than the reactants.
- B) The sign of H is *positive*, and the products have *more* potential energy than the reactants.
- C) The sign of H is *negative*, and the products have *less* potential energy than the reactants.
- D) The sign of H is *negative*, and the products have *more* potential energy than the reactants.

15. Which conditions will increase the rate of chemical reaction?

- A) Decreased temperature and decreased concentration of reactants.
- B) Decreased temperature and increased concentration of reactants.
- C) Increased temperature and decreased concentration of reactants.
- D) Increased temperature and increased concentration of reactants.

16. Which compound undergoes solvolysis in aqueous ethanol most rapidly?
[Remember: solvolysis refers to ionization of the molecule aided by the solvent.]

- A) cyclohexyl bromide
- B) isopropyl chloride
- C) methyl iodide
- D) 3-iodo-3-methylpentane

17. Which halide has the smallest dipole moment?

- A) CH_3F
- B) CH_3Cl
- C) CH_2Cl_2
- D) CF_4

18. Life on earth was originated in:

- A) reducing environment
- B) oxidizing environment
- C) chlorinated environment
- D) brominated environment

19. Urea in our body is synthesized in:

- A) Kidney
- B) Liver
- C) Spleen
- D) Urinary bladder

20. Wings of insects and birds have become flat, large and streamlined. This is an example of:

- A) Convergent evolution
- B) Parallel evolution
- C) Divergent evolution
- D) Co-evolution

21. When monkey sees a snake even for the first time, it experiences fear. This is because:

- A) the monkey has learned to beware of snakes from its parents.
- B) the monkey is frightened by any novel experience.
- C) natural selection has led monkeys having an instinctive fear of snakes.
- D) the monkey logically deduces that the snake must be dangerous.

22. Among the following, which is a sex-linked disorder?

- A) Night blindness
- B) Colour blindness
- C) Cretinism
- D) Myxodema

23. Receptors for neurotransmitters are located on the:

- A) nucleus
- B) endosome
- C) Golgi apparatus
- D) cell surface

24. Human red blood cells (RBCs) cannot be grown in culture because:

- A) the culture medium which supports the growth of RBCs has not been defined yet.
- B) RBCs are extremely fragile.
- C) RBCs are terminally differentiated cells lacking nucleus.
- D) All of above.

25. The minimum distance at which a microscope is capable of distinguishing two points as separate is its:

- A) Magnification
- B) Illumination
- C) Resolving power
- D) Fluorescence

PART B

[These questions may have one or more right answers. Mark all the right answers and only the right answers. For instance, if there are three right answers to a particular question, you have to mark all the three right options. Marking one, two or four will be considered as wrong answer. There is no negative marking for incorrect answers in this part]

26. In 2nd order phase transitions which variables show discontinuities while passing from one phase to the other.

- A) Volume.
- B) C_p – specific heat at constant pressure.
- C) Entropy.
- D) Isobaric volume expansibility.

27. The real gases, as distinct from ideal gases, are characterised by

- A) Finite size of the molecules.
- B) Existence of intermolecular force field.
- C) Obeying $PV = RT$ equation.
- D) Obeying $(P+a/V^2)(V - b) = RT$ equation.

28. Which of the following statements about functional tRNA are correct?

- A) They contain many modified nucleotides.
- B) About half of their nucleotides are in base-paired helical regions.
- C) They contain fewer than 100 ribonucleotides.
- D) They have a terminal AAC sequence at their amino acid accepting end.

29. Genetic suppression involves

- A) Two different phenotypes.
- B) Two different mutations in one gene.
- C) Mutation in two genes.
- D) Two proteins that interact.

30. The technical problems that have hampered widespread use of gene therapy include

- A) Developing reliable methods for introducing genes into cells.
- B) Obtaining sufficient amounts of DNA to carry out the procedures.
- C) Insuring appropriate tissue-specific expression.
- D) Developing methods for obtaining long stretches of DNA that contain complete gene.

31. According to the molecular definition of a gene, which of the following elements can be part of a eukaryotic gene?

- A) Promoter
- B) Enhancer
- C) Sequences not translated into protein
- D) Poly A-signal

32. DNA synthesis begins

- A) at a single location in *E. coli*.
- B) at a single location in SV40 genome.
- C) at a single location in yeast.
- D) at a site(s) that is G-C rich in *E. coli*.

33. Repair of damaged DNA _____ .

- A) can occur spontaneously because of the nature of the chemical bonds in DNA.
- B) can occur during normal replication of DNA.
- C) may require excision and resynthesis of affected DNA.
- D) is carried by enzymes that cause disease if mutated.

34. Transcriptionally inactive genes _____ .

- A) may be located within heterochromatin.
- B) often are methylated.
- C) are resistant to DNaseI.
- D) always are associated with repressors.

35. First cells to be differentiated in a developing embryo are:

- A) Epithelial cells
- B) Rods
- C) RBCs
- D) Nerve cells

36. Homeotic genes are responsible for:

- A) Homeostasis
- B) Hematopoiesis
- C) Development
- D) Cell cycle

37. The theory of *evolution by natural selection* was first proposed by:

- A) Charles Darwin
- B) Lamarck
- C) Alfred Russel Wallace
- D) Gregor Johann Mendel

38. Depolarization of neuronal membrane during the propagation of nerve impulse or action potential involves:

- A) entry of potassium ions to the neuron
- B) entry of calcium ions to the neuron
- C) entry of chloride ions to the neuron
- D) entry of sodium ions to the neuron

39. Dynamins and related proteins

- A) generally involved in endocytosis
- B) require GTP for their activity
- C) require ATP for their activity
- D) involved in the fission of mitochondria

40. The oxygen transporting molecules in nature are:

- A) Hemocyanin
- B) Myoglobin
- C) Hemoglobin
- D) Hemerythrin

41. Ryanodine receptors are involved in:

- A) release of calcium from endoplasmic reticulum.
- B) exchange of calcium at the plasma membrane.
- C) pumping of calcium into mitochondria.
- D) release of calcium from mitochondria.

42. You designed a new molecule that was observed to block the transporter for H^+ secretion in gastric parietal cells. Which of the following processes is/are being inhibited?

- A) Simple diffusion
- B) Facilitated diffusion
- C) Primary active transport
- D) Cotransport

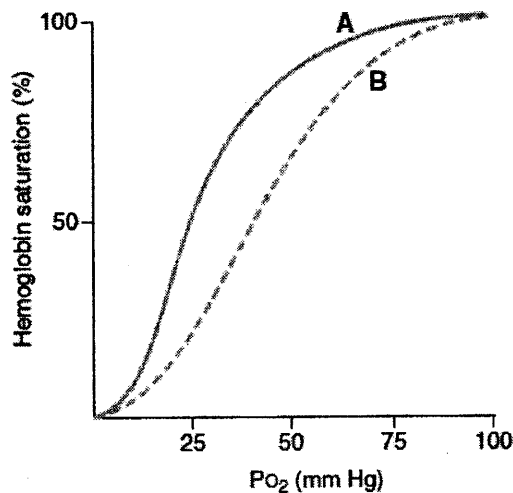
43. Contraction of cardiac muscles is best correlated with the intracellular concentration of

- A) Na^+
- B) K^+
- C) Ca^{2+}
- D) Mg^{2+}

44. What is the structural feature common to FAD, NAD^+ and CoA?

- A) An ATP unit
- B) An ADP unit
- C) A FMP unit
- D) A triad of His-Ser-Asp

45. Which of the following will shift the hemoglobin- O_2 dissociation from curve A to curve B?



- A) increased pH
- B) decreased 2,3-diphosphoglycerate (DPG) concentration
- C) decreased pH
- D) carbon monoxide (CO) poisoning

46. Citric acid cycle (TCA) is regulated by several enzymes within the cycle. However, there are two enzymes outside the cycle that strongly affect the TCA cycle. Identify the pair of enzymes from the choices given below.

- A) Ornithinecarbamoyl transferase and carbamoyl phosphate synthase
- B) Lactic acid dehydrogenase and pyruvate kinase
- C) Glucokinase and phosphofructokinase
- D) Pyruvate carboxylase and pyruvate dehydrogenase

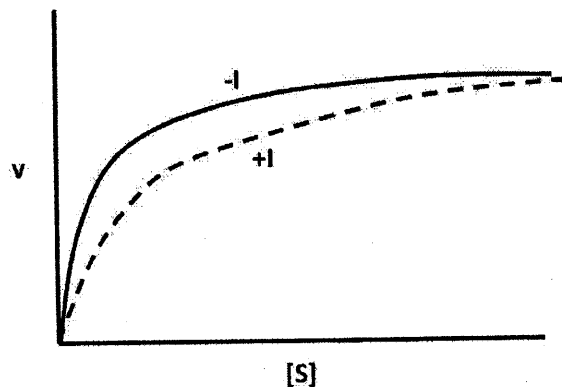
47. Given that a mole of NADH to be equivalent in energy to 2.5 ATP and a mole of FADH_2 to be equivalent in energy to 1.5 ATP, what is the total number of moles of ATP that could be generated by oxidation of a mole of pyruvic acid via the citric acid cycle?

- A) 10.0
- B) 12.5
- C) 15
- D) 17.5

48. FADH_2 and NADH generated during TCA cycle pass their electrons into the electron transport chain to produce ATP. Identify the high-energy compound generated in TCA cycle that can provide energy for phosphorylation of ADP at the substrate level.

- A) Isocitric acid
- B) Fumaric acid
- C) Succinyl CoA
- D) Citric acid

49. Given below is Michaelis–Menten plot of a reaction, in absence (-I) or presence (+I) of an inhibitor. What can you say about the nature of the inhibitor?



- A) It is a competitive inhibitor.
- B) It is a non-competitive inhibitor.
- C) It is an uncompetitive inhibitor.
- D) It is an allosteric inhibitor.

50. Frogs undergo metamorphosis, where the water dwelling tadpoles mature into four-legged land organisms. How does the nitrogen metabolism change as they grow from tadpole to frog?

- A) Starts as ammonotelic and becomes ureotelic
- B) Starts as ureotelic and becomes ammonotelic
- C) Starts as uricotelic and becomes ammonotelic
- D) Starts as uricotelic and becomes ureotelic

51. When one mole of glutamic acid is combined with one mole of sodium hydroxide it makes a substance that is used as a meat tenderizer. What is that?

- A) Disodium glutamate
- B) The hydrochloride salt of glutamic acid
- C) Soy sauce
- D) Monosodium glutamate

52. Which of the following is an example of active immunity?

- A) A child born to a mother suffering from chicken pox was immune to chicken pox infection.
- B) A child given anti-rabies antibodies after a dog bite
- C) A child gets cow pox virus infection, but was found immune to small pox virus
- D) A child given anti-venom after snake bite

53. Immunoglobulin G (IgG), an antibody isotype, is a protein complex of peptide chains connected by disulphide linkages. If IgG is treated with reducing agent like β mercaptoethanol, the peptides generated will be:

- A) 1 peptide of 25 kDa and 3 peptides of 50 kDa
- B) 2 peptides of 50 kDa and 3 peptides of 25 kDa
- C) 2 peptides of 25 kDa and 2 peptides of 50 kDa
- D) 3 peptides of 25 kDa and 3 peptides of 50 kDa

54. Arrange the following events in the order that they occur during helper T cell activation as an antigen is recognized by T-cells.

1. interleukin-1 released by macrophage (costimulation)
2. antigen processed by macrophage
3. helper T cell binds to macrophage
4. helper T cell releases interleukin-2 and divides
5. antigen displayed on MHC molecule

- A) 1,4,2,5,3
- B) 2,5,3,1,4,
- C) 3,1,4,2,5
- D) 4,2,5,3,1

55. Which of the following is NOT an example of delayed type of hypersensitivity?

- A) A person developing rashes upon wearing a nickel chain
- B) Tuberculin skin test for detection of tuberculosis
- C) Sneezes and asthma like breathlessness due to pollens in air
- D) A child come in contact with poison Ivy and develops blisters

56. One of the following is a mobile electron carrier protein in the linear photosynthetic electron transport

- A) Plastocyanin
- B) Plastoquinone
- C) Cytochrome f
- D) Cytochrome b6

57. Nitin crossed two bean plants and looked at the seeds obtained in the progeny. He found that he had 492 plants with black seeds and 162 plants with white seeds. Black (B) is dominant over white (b). What is the most probable genotype of the parents?

- A) $Bb \times Bb$
- B) $BB \times Bb$
- C) $BB \times bb$
- D) $Bb \times bb$

58. About 80% of the human population can smell the jasmines, while the other 20% can't. This trait is governed by a single gene J with 2 alleles (J and j). What does this statistic tell us about the trait?

- A) Allele for smelling jasmines is dominant over allele for not smelling jasmines.
- B) Smelling jasmines is a codominant trait in humans
- C) The distribution does not fit with a single gene trait
- D) This data given is not sufficient to determine anything about the trait.

59. Which of the following genotype of the parents can produce a child with blood group A?

- A) $AO \times AO$
- B) $AB \times AB$
- C) $BO \times AO$
- D) $AA \times BO$

60. A plant with purple flowers is crossed with a plant of the same phenotype. Among the offspring, 11 plants produce purple flowers, 6 are red and 8 are blue. The simplest explanation for this observation is

- A) Blue is dominant over red.
- B) Red and blue flowers are recessive over purple.
- C) It is a case of incomplete dominance.
- D) Purple flowered plants are heterozygous for red and blue pigment.

61. If a coin is tossed and a dice is rolled what is the probability of observing a tail in the coin OR number 4 in the dice?

- A) $1/12$
- B) $7/8$
- C) $7/12$
- D) $1/6$

62. For a dataset with mean value of 20 and variance of 4, the coefficient of variance is equal to

- A) 0.2
- B) 0.1
- C) 5
- D) 10

63. The electron bound to the hydrogen atom in its normal state has energy

- A) 13.6 eV
- B) 109677 cm^{-1}
- C) 0.529 \AA
- D) $60.5 \times 10^{-26} \text{ KWH}$

64. A room can be heated

- A) electrically with a coil made of nichrome.
- B) electrically with a coil made of copper.
- C) by circulating hot water through pipes.
- D) by refrigerating the outdoors.

65. The value of g (acceleration due to gravity) at a place on the surface of the earth [at sea level] depends on

- A) Its longitude.
- B) Its distance from the center of the earth.
- C) Its latitude.
- D) Diurnal rotation of the earth.

66. For a reversible cell the extensive parameters according to thermodynamic definitions are

- A) temperature
- B) mass
- C) charge
- D) E.M.F.

67. Which of the following properties requires the help of 2nd law of thermodynamics for its explanation ?

- A) Impossibility of perpetual motion of 2nd kind.
- B) Conservation of energy principle.
- C) Natural tendency to proceed towards greater disorder.
- D) Non attainability of absolute zero by any number of finite processes.

68. A thermodynamic system may go from one state to another by different paths. Which of the following quantity / quantities is/ are independent of the path?

- A) ΔQ
- B) ΔH
- C) ΔW
- D) ΔU

69. A Carnot engine whose low temperature reservoir is at 27°C has an efficiency of 40%. It is desired to increase its efficiency to 50%. By how many degrees should the temperature of the source be increased ?

- A) 100 °C
- B) 600 °K
- C) 500 °C
- D) 100 °K

70. If a missile is projected such that it never returns to earth, its velocity shall be

- A) 26000 m.p.hr
- B) 8 m.p.sec
- C) 50000 km.p.hr
- D) 15000 m.p. hr.

PART C

[Each question has only one right answer. Mark the right answer. Each question carries two marks. There is negative marking. 0.66 marks will be deducted for each wrong answer]

71. Consider a spherical eukaryotic cell that is 20 μm in diameter and a virus that is a cube with sides of 200 \AA . The maximum number of virus particles that could adhere to the surface of the cell would be:

- A) 3×10^{16}
- B) 3×10^9
- C) 3×10^6
- D) 3×10^3

72. How long does it take to synthesize a protein of molecular weight 50,000 at 37°C?

- A) 17 sec.
- B) 27 sec.
- C) 63 sec.
- D) 87 sec.

73. What is the probability that the imidazole ring of histidine will be charged at pH 7?
[Given that the pK_a value for the ring is 6.0]

- A) 0%
- B) 9%
- C) 27%
- D) 90%

74. *E. coli* has a cylindrical shape about 1 μm in diameter and 3 μm long. The doubling time of *E. coli* when growing on nutrient agar is about 25 minutes. After 12 hours of growth, a colony is roughly 2 mm in diameter and $\frac{1}{2}$ mm high. How many cells does the colony contain?

- A) 10^5 cells
- B) 10^7 cells
- C) 10^9 cells
- D) 10^{11} cells

75. Four genes *kyuA*, *kyuB*, *kyuC*, and *kyuQ* are required to synthesize substance Q from P in the reaction sequence $P \rightarrow B \rightarrow C \rightarrow A \rightarrow Q$. Each of these biochemical reactions can be detected. The product of a gene *kyuA* is needed to synthesize substance A from C. Similarly product of gene *kyuB* is needed to synthesize B from P; product of gene *kyuC* is needed to synthesize C from B; and product of gene *kyuQ* is needed to synthesize Q from A. Addition of radio labeled ^{14}C -P yields ^{14}C -Q. A mutant is found for which addition of ^{14}C -P yields ^{14}C -A, but no ^{14}C -Q. In what gene is the mutation?

- A) *kyuA*
- B) *kyuB*
- C) *kyuC*
- D) *kyuQ*

76. The initial velocity, V_0 , of an enzyme catalyzed reaction reaches V_{max}

- A) at $[S] = K_m$.
- B) at $[S] = 10 \times K_m$.
- C) at $1/[S] = 1/K_m$.
- D) only as $1/[S] \rightarrow 0$

77. The Nernst equation is used to calculate equilibrium potentials where,

$$E = -2.3 RT/zF \log_{10} [C_i]/[C_e].$$

What is the equilibrium potential for Na⁺ if the intracellular [Na⁺] is 15 mM and the extracellular [Na⁺] is 150 mM?

[Given that $2.3 RT/zF = 60\text{mV}$ at 37°C , z =charge on the ion, C_i = intracellular concentration (mM), C_e = extracellular concentration (mM)]

- A) +60mV
- B) -60mV
- C) +0.60mV
- D) -0.60mV

78. The complementation data shown in the accompanying table are observed. The numbers refer to particular mutations. The symbols + and - indicate that the two mutations do and do not complement respectively. Which mutations are on the same gene?

	Mutants						
	1	2	3	4	5	6	7
1	-	+	+	+	+	+	-
2		-	+	-	+	+	+
3			-	+	+	-	+
4				-	+	+	+
5					-	+	+
6						-	+
7							-

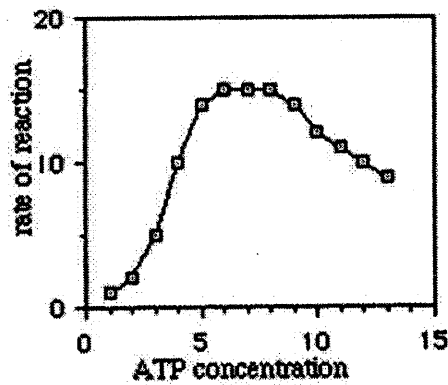
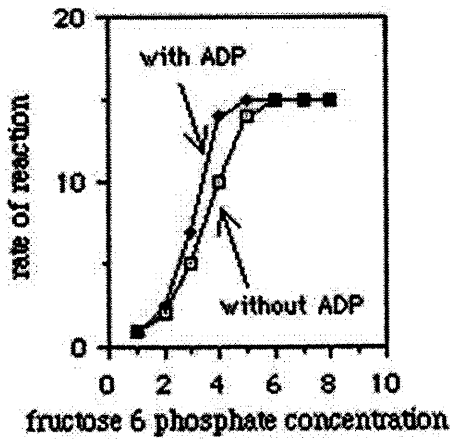
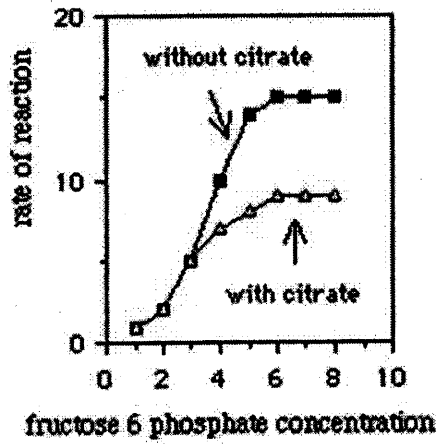
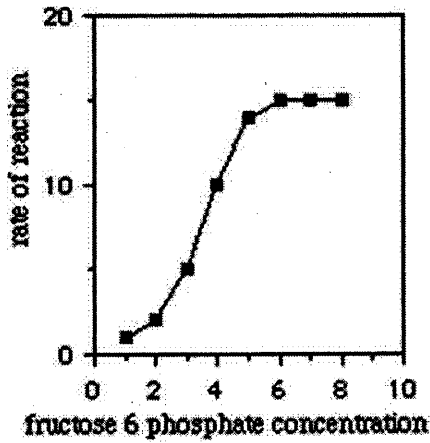
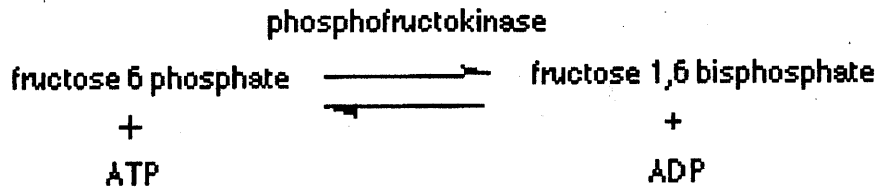
- A) 1 and 4
- B) 2 and 5
- C) 3 and 6
- D) 4 and 5

79. Penicillin is a hapten. A mouse was injected with penicillin that was covalently bound to bovine serum albumin. At the same time, the same mouse was also injected with egg albumin to which no penicillin was bound. Of the following, which one will induce a secondary response to penicillin when injected into the mouse 1 month later?

- A) Penicillin
- B) penicillin bound to egg albumin
- C) egg albumin
- D) bovine serum albumin

Use the following figures to answer the next 2 questions:

Given below are the plots showing the effects of various compounds on the rate of the reaction by phosphofructokinase. The reaction is given below:



80. From the reaction and the plots given, how many chemically different substances may bind to the enzyme phosphofructokinase?

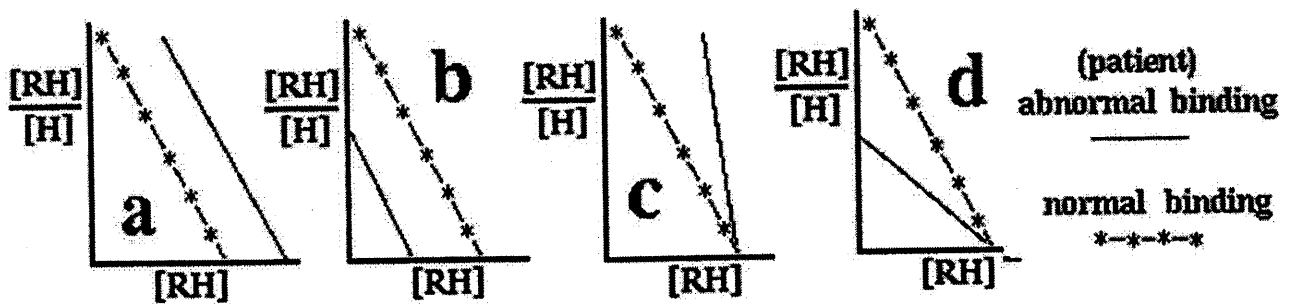
- A) 1
- B) 5
- C) 3
- D) 2

81. From the data presented above, which of the following can be the inhibitor of the enzyme phosphofructokinase?

- A) citrate
- B) ADP
- C) fructose 1,6 bisphosphate
- D) AMP

82. Shown here are Scatchard plots ($\frac{[RH]}{[H]}$ vs $[RH]$) for the binding of a antigen (H) to the antibody (R) of a normal individual (---; shown in each plot) and four abnormal individuals (plots a. to d. in thin solid line). $[RH]$ = concentration of bound antigen. $[H]$ = concentration of free antigen.

By comparison with the normal individual, in which individual the antibody binds with equal affinity, but shows a decreased number of binding sites?



- A) Plot a
- B) Plot b
- C) Plot c
- D) Plot d

83. A woman and her brother are born with red-green colour-blindness. Their mother has a normal vision. This form of colour-blindness is caused by an X-linked recessive gene. Can you determine what their father's phenotype is and the mother's genotype is?

- A) It is not possible to determine the father's phenotype or mother's genotype with this information
- B) The father is colour blind, mother is heterozygous for colour blindness
- C) Father is normal and mother is heterozygous for colour blindness
- D) Mother and father are heterozygous for colour blindness.

84. You are studying two traits in mice: coat colour (black or white) and tail (long or short). In a cross of a black, long tailed mouse, heterozygous for both traits, with a white short tailed mouse, you find only parental types: black, long tailed progeny and white tail-less progeny in equal numbers. What is the likely explanation?

- A) Black is dominant over white
- B) Coat colour and tail length genes are tightly linked
- C) Both are co-dominant traits
- D) The traits show incomplete dominance

85. You have a liquid culture of yeast *Saccharomyces cerevisiae*. You have diluted it 10^5 fold and plated 0.1 ml of the diluted culture on a solid agar plate to obtain 63 colonies. What was the OD_{600} of the initial culture? [Given that $1OD_{600} = 3 \times 10^7$ cells/ml.]

- A) 0.21
- B) 0.33
- C) 2.1
- D) 3.3

Rough work: