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Answer Key

CHAPTER-1 BIOCHEMISTRY

Section A: Atom, Molecule, Bonds & Interactions

1. Which of the following does *not* participate in the formation of antigen-antibody/ligand-receptor complexes?
   (1) Hydrophobic bonds
   (2) Covalent bonds
   (3) Electrostatic interactions
   (4) Hydrogen bonds
2. Which of the following interaction provide maximum strength in antigen-antibody interactions?
   (1) Hydrophobic interaction (2) Peptide bond
   (3) Hydrogen bond (4) Ionic bond
3. 6M Guanidium hydrochloride is known to denature a number of proteins. Such a high concentration is able to break down the noncovalent forces sustaining the structure of proteins by affecting
   (1) Electrostatic interactions only
   (2) Electrostatic and hydrophobic interactions
   (3) Intrapeptide hydrogen bonding only
   (4) Electrostatic, hydrophobic, and hydrogen bonding interactions.
4. Sodium dodecyl sulphate, an anionic detergent commonly used in SDS-Polyacrylamide gel electrophoresis, works in facilitating electrophoretic separation of a mixture of proteins by its ability to bind to the
   (1) negatively charged amino acid side chains in proteins
   (2) hydrophobic side chains in proteins
   (3) positively charged amino acid side chains in proteins
   (4) peptide group in proteins
5. Four proteins (P1, P2, P3 and P4) have 17, 10, 21 and 14 percent hydrophobic amino-acids respectively. The order of precipitation of these proteins using ammonium sulphate will be
   (1) P3, P1, P4, P2 (2) P3, P1, P2, P4
   (3) P2, P4, P3, P1 (4) P2, P4, P1, P3
6. The dielectric constant of protein interiors is likely to be
   (1) Similar to that of water's, i.e. close to 80
   (2) Much smaller than that of water
   (3) Much more than that of water
   (4) At some places in the interior more and at some other places less than that of water
7. Which of the following physiochemical property is manifestation of charge separation?
   (1) Pauling electronegativity
   (2) Isolated π-orbital overlap
   (3) Aromaticity
   (4) Dielectric constant
8. If the strength of ionic integrations in air or vacuum is 400 Kcal/mole, what will be its strength in aqueous environment?
   (1) 5 kcal/mole (2) 4 kcal/mole
   (3) 10 kcal/mole (4) 40 kcal/mole
9. The potential energy for the interaction of two atoms is given by $U = A/r^{12} – B/r^6$. The bottom of the potential well corresponds to
   (1) the sum of van der Waals radii of the atoms
   (2) the existence of the maximum electrostatic interaction
   (3) the situation when the first term vanishes
   (4) the situation when the atoms get bonded covalently
10. The attractive energy parameter in non-bonded interactions explained by London dispersion force is
    (1) $-A/r^6$ (2) $-A/r^{12}$
    (3) A/r^6 (4) A/r^{12}
11. The dominant interaction that drives a water-soluble protein to fold is:
    (1) H-bonding
    (2) formation of strong, covalent bonds
    (3) the hydrophobic interaction
    (4) charged and polar residues on the outside, in contact with the water
12. The strength of the hydrogen bond represented by D-H...A (where D is the donor atom, H is the hydrogen atom and A is the acceptor atom) depends on
    (1) the D-H bond length and the nature of the D and A atoms.
    (2) the nature of the D and A atoms and the D...A distance.
    (3) the D...A distance and linearity of the angle DHA.
    (4) the H...A distance, linearity of the angle DHA and the nature of the atoms D & A.

13. Assuming that the sequence of CDRs of an antibody are heavily enriched with Tyrosine and Serine, what is likely to be the driving force stabilizing its interaction with the antigen?
    (1) Hydrophobic interaction
    (2) Hydrogen bonding
    (3) Van-der Waals interaction
    (4) Covalent interactions
14. Among the following which is weakest interaction?
    (1) Vander wall interaction
    (2) Ionic interaction in non-polar environment
    (3) Hydrogen bonding
    (4) Hydrophobic interaction
15. Which of the following interaction would be observed among non-polar molecules?
    (1) Hydrophobic interactions
    (2) Hydrophilic interactions
    (3) London dispersion force
    (4) Hydrogen bonding
16. The van der Waals energy of a single water molecule:
    (1) 0 (2) -0.2 Kcal/mol
    (3) -0.5 Kcal/mol (4) 0.2 Kcal/mol
17. The major difference between hormones that have intracellular receptors and those that have cell membrane receptors is that the former is usually:
    (1) Charged (2) Hydrophilic
    (3) Glycosylated (4) Hydrophobic
18. If side chains of amino acids interact with each other, which of the following would be termed as a salt bridge?
    (1) Tyr- Phe (2) Cys- Cys
    (3) Lys- Glu (4) Ala- Val
19. Sulphur is in the same column of the periodic table as oxygen, but has electronegativity similar to carbon. Compared to water molecules, molecules of H_2S
    (1) will ionize more readily.
    (2) will have greater cohesion to other molecules of H_2S.
    (3) will have a greater tendency to form hydrogen bonds with each other.
    (4) will not form hydrogen bonds with each other
20. Change in entropy of polar solutes when added in water is
    (1) 0
    (2) positive
    (3) negative
    (4) cannot be predicted
21. Water has a high dielectric constant value of 80. Because of its presence in biological systems compared with low dielectric solvents like hydrocarbons, it should
    (1) strengthen electrostatic and hydrophobic interaction
    (2) weaken electrostatic interaction but strengthen hydrophobic interactions
    (3) weaken electrostatic and hydrophobic interactions
    (4) Strengthen electrostatic but weaken hydrophobic interactions
22. With reference to protein precipitation by organic solvents, which one of the following statements is correct?
    (1) It is not influenced by pH.
    (2) It is dependent on the change in dielectric constant.
    (3) It is unaffected by ionic strength.
    (4) It is independent of the molecular size of the protein.
23. Water has a high dielectric constant of 80 in contrast with many nonpolar solvents having a very low dielectric constant. Due to this property, the electrostatic interactions between various charged side chains of amino acids in proteins after their transfer from a nonpolar solvent to water would
    (1) decrease
    (2) increase
    (3) remain unaffected
    (4) attain a value of zero
24. Which of the following cannot be classified as a weak interaction?
    (1) van der Waals force (2) Peptide bond
    (3) Hydrogen bond (4) Ionic interaction
25. Which of the following statements are TRUE for hydrogen bonds? Strength of hydrogen bond is
    (1) high in a solvent of high dielectric constant
    (2) low in a solvent of low dielectric constant
    (3) lower in water as compared to organic solvents
    (4) higher in water as compared to organic

Section B: Solution, pH and Buffer

1. How many millilitres of 0.05 N HCl are required to neutralize eight grams of NaOH?
    (1) 5000 (2) 4000
    (3) 4500 (4) 5050
2. The pH of a 0.001 molar HCl solution in H_2O is:
    (1) 1 (2) 2
    (3) 3 (4) 4

3. What will be the required volumes of 1N HCl and 4N NaOH to prepare one litre solution of pH 7?
   (1) 500 ml; 500 ml (2) 800 ml; 200 ml
   (3) 600 ml; 400 ml (4) 200 ml; 800 ml
4. If 5 ml of 20% ethanol is mixed with 25 ml of 80% ethanol, the resulting solution will approximately be:
   (1) 50% ethanol (2) 70% ethanol
   (3) 100% ethanol (4) 80% ethanol
5. If you were to take 1.0 ml of a solution of HCl with a pH of 4.0 and add it to 9.0 ml of distilled water, what would be the pH of the final solution?
   (1) The pH would remain unchanged.
   (2) The pH would rise to 5.5.
   (3) The pH would rise to 5.0.
   (4) The pH would rise to 7.0.
6. If the pH of a solution goes from 8 to 7, this means that the hydrogen ion concentration has:
   (1) decreased by 1 mole/liter.
   (2) increased by 1 mole/liter.
   (3) decreased 10 fold.
   (4) increased 10 fold.
7. If the intracellular pH of a cell becomes basic, which one of the following will help reduce the pH?
   (1) Export of Cl^- and import of HCO_3^-
   (2) Import of Cl^- and export of HCO_3^-
   (3) Import of Na^+ and HCO3- and export of Cl^-
   (4) Export of Na^+ and Cl
8. Two solutions of a substance (non-electrolyte) are mixed in the following manner: 480 ml of 1.5 M first solution + 520 ml of 1.2 M second solution. What is the molarity (M) of the final mixture?
   (1) 1.250 (2) 1.344
   (3) 1.433 (4) 1.479
9. A TE buffer contains 200 mM Tris and 50 mM EDTA. Given the stock solutions – 0.5 M Tris and 0.5 M EDTA, volumes of stock solutions required to make 1 liter of buffer solution are respectively:
   (1) 400 ml, 100 ml (2) 200 ml, 50 ml
   (3) 500 ml, 125 ml (4) 100 ml, 25 ml
10. While making 100 ml of 2M NaCl solution, a student left the solution on a heating platform reducing the volume by 50 ml. This solution was diluted 1:100 for use. What is the final concentration of NaCl in this solution?
    (1) 20 mM (2) 80 mM
    (3) 40 mM (4) 400 mM
11. The pH of the blood can be maintained by
    (1) Myoglobin
    (2) globulins
    (3) albumins
    (4) carbonate/bicarbonate salt
12. Which one of the following amino-containing buffering molecules will be the most able to resist change in pH when in a pH 7.0 solution at a total (ionized and non-ionic) concentration of 100mM?
    (1) Tris (pKa = 8.1) (2) HEPES (pKa = 7.7)
    (3) MOPS (pKa = 7.3) (4) PIPES (pKa = 7.1)
13. The pKa of acetic acid is 4.76. At what pH would the concentration of acetic acid and acetate ion be the same?
    (1) pH= 7 (2) pH = 6.7
    (3) pH = 9.8 (4) pH = 4.76
14. A 10 N HCl solution was diluted 10-fold with water and the pH of the diluted solution was measured with a pH meter after calibration using standard solutions. Given that the activity coefficient for diluted HCI was 0.01, the pH of the solution would be
    (1) 0 (2) 1
    (3) 2 (4) 2.5
15. If pH of solution of NaOH is 12.0 the pH of H_2SO_4 solution of same molarity will be
    (1) 2.0 (2) 12.0
    (3) 1.7 (4) 10.0387
16. What is the concentration of OH^- in a solution with a H^+ concentration of 1.3×10^{-4} M?
    (1) 7.7×10^{-10} M (2) 7.7×10^{-9} M
    (3) 7.7×10^{-11} M (4) 7.7×10^{-12} M
17. Tris hydroxyethyl aminoethane (THAE) has a pK_a of 8.4. The buffering capacity of a buffer made with this compound will be greatest at which pH?
    (1) pH 9.4
    (2) pH 7.4
    (3) pH 8.4
    (4) Both at pH 7.4 and 9.4
18. If you mix equal volumes of pH 4.0 and pH 6.0 solutions, what will be the approximate pH of the final solution?
    (1) 7.0 (2) 3.7
    (3) 5.0 (4) 4.3
19. Which of the following will have maximum effect on lowering in vapour pressure if added in equimolar concentration?

(1) Sucrose (2) Glucose
(3) NaCl (4) $CaCl_2$

20. Osmotic pressure does not depend on
(1) Temperature (2) Degree of ionization
(3) Molecular weight (4) Molar concentration

21. Within the aqueous environment of an animal cell, sugars are stored as polymers rather than as monomers. If the sugars were stored as monomers instead of polymers, which of the following properties would be LEAST affected?
(1) Freezing point (2) Osmotic pressure
(3) Viscosity (4) pH

22. Which of the following is not a colligative property, which arises in systems when there is addition of solute?
(1) Lowering of vapour pressure
(2) Lowering of melting point
(3) Lowering of boiling point
(4) Increase of osmotic pressure

23. You have a freshly prepared 0.1 *M* solution of glucose in water. Each liter of this solution contains how many glucose molecules?
(1) 6.02×10^{23} (2) 3.01×10^{23}
(3) 6.02×10^{24} (4) 6.02×10^{22}

24. While making 100 ml of 2M NaCl solution, a student left the solution on a heating platform reducing the volume by 50 ml. This solution was diluted 1:100 for use. What is the final concentration of NaCl in this solution?
(1) 20 Mm (2) 80 mM
(3) 40 mM (4) 400 mM

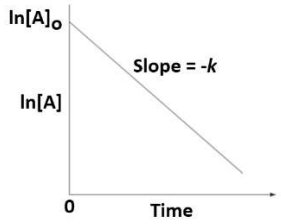
25. What would be the number of protein molecules present in 1.0 mg of protein having a molecular weight of 25 kDa?
(1) 2.4×10^{15} (2) 2.4×10^{16}
(3) 2.4×10^{17} (4) 2.4×10^{18}

26. The total number of cells in the body of an individual is 6×10^{15}. If he is administered with 5.8 mg of insulin (MW:5808 Da), how many molecules will be there in each cell (presume that the drug penetrates all cells in, the body with equal efficiency)?
(1) 100 (2) 10
(3) 1000 (4) 10000

27. Sucrose is a disaccharide with molecular weight of 342 Daltons, preparing 500 ml of 0.1M solution would require.
(1) 17.1 gm of sucrose (2) 0.171 gm of sucrose
(3) 1.71 gm of sucrose (4) 171 gm of sucrose

28. In which of the following reactions, is the unit of rate constant and rate of reaction the same?
(1) 1^{st} order reaction (2) 2^{nd} order reaction
(3) 3^{rd} order reaction (4) Zero order reaction

29. The plot between ln[K] and time for a chemical reaction is shown below



This graph suggest that reactions is
(1) Zero Order (2) First Order
(3) Second Order (4) Mixed Order

30. Thallium-208 has a half-life of 3.053 min. How long will a sample containing 120.0 µCi of Thallium-208 take to decay to 7.50 µCi?
(1) 6.11 min. (2) 9.36 min.
(3) 12.21 min. (4) 18.46 min.

31. You are provided with 1.0*M* solutions of NaCl, $(NH_4)_2SO_4$, $MgSO_4$ and K_3PO_4. In which of these solutions would a protein be expected to be lest soluble?
(1) NaCl (2) $(NH_4)_2SO_4$
(3) $MgSO_4$ (4) K_3PO_4

32. What will be the ionic strength of 0.1 M $(NH_4)_2SO_4$?
(1) 0.2 (2) 0.4
(3) 0.6 (4) 0.8

33. Which of the following salt is the most commonly used reagent for salting out proteins because its high solubility (3.9M in water at 0°C) permits the achievement of solutions with high ionic strengths (up to 23.4 in water at 0°C)?
(1) Ammonium sulfate ($(NH_4)_2SO_4$)
(2) Sodium chloride (NaCl)
(3) Magnesium sulfate ($MgSO_4$)
(4) Potassium chloride (KCl)

34. Aqueous environment in a spherical endosome – a closed vesicle of 100 nm diameter, is at a pH 5.0, in order to denature and hydrolyze the material internalized by a cell. Assuming Avogadro's number to be 6×10^{23}, the number of free protons in an endosome is closest to
(1) 24 (2) 3
(3) 2400 (4) 300

35. The number of water molecules present in a 300 residue soluble protein of spherical shape (diameter = 2nm) having 20% (V/V) water is closest to *Assume:* density of water = 1000 kg/m^3, Avogadro's number = 6 × 10^{23}.
(1) 224 (2) 9
(3) 140 (4) 28

Section C: Bioenergetics

1. Which of the following statements will always apply when a reversible chemical reaction has attained equilibrium?
(1) All reactants will convert to products
(2) The reaction proceeds alternately in the forward and reverse directions
(3) The Gibbs free energy of the system reaches a minimum
(4) The forward reaction will dominate over the reverse reaction
2. In which one of the following situations, the entropy may be maximum?
(1) A class full of students without the teacher being present
(2) A class full of students with teacher being present
(3) A class full of students answering an annual examination monitored by video camera
(4) An empty class room
3. If enthalpy change for a reaction is zero, then ΔG° equals to
(1) -TΔS° (2) TΔS°
(3) -ΔH° (4) *ln* keq
4. Which one of the following equations defines the enthalpy of reaction, *ΔH,* for a reaction occurring at constant pressure that does expansion work?
(1) $\Delta H = \Delta U$ (2) $\Delta H = \Delta U + P\Delta V$
(3) $\Delta H = \Delta G - T\Delta S$ (4) $\Delta H = q + w$
5. Which of the following statement is NOT true?
(1) First law of thermodynamics suggest that energy is conserved in universe
(2) Second law of thermodynamics the universe tends toward maximum disorder
(3) Standard free energy change ($\Delta G^{o'}$) is the indicator of spontaneity under cellular physiological conditions
(4) The standard free energy change ($\Delta G^{o'}$), is the free energy change at 25°C, 1 atm pressure, and unit activities of reactants and products in dilute aqueous solution at pH 7.
6. Given the following values of ΔH and ΔS, which one of the following processes can take place at 300°K without violating the second law of thermodynamics?

	ΔH (Kcal.Mol^{-1})	ΔS (cal.$Mol^{-1}.°K^{-1}$)
1.	-20	+80
2.	-20	-80
3.	+20	+30
4.	+20	-30

7. The ΔG^0(Kcal/mol) values for K_{eq} of 0.1, 0.01 and 0.001 are 1.36, 2.72 and 4.09, respectively. It can be concluded that the relationship between ΔG and K_{eq} is
(1) Parabolic (2) Exponential
(3) Hyperbolic (4) Linear
8. What will be change in enthalpy, entropy and free energy during protein folding will be?
(1) Positive for entropy and negative for enthalpy and free energy
(2) Negative for entropy and enthalpy but positive for free energy
(3) Negative for entropy, enthalpy and free energy
(4) More than zero for entropy and free energy but less than zero for free energy
9. A chemist optimizes a chemical reaction such that product concentration exceeds the concentration of the reactants. What conclusions can be drawn about Keq and ΔG^O in this reaction?
(1) Keq >1, ΔG^O>0 (2) Keq >1, ΔG^O<0
(3) Keq<1, ΔG^O>0 (4) Keq<1, ΔG^O<0
10. If the equilibrium constant for a chemical reaction at 20^0C is 20, the standard free energy change associated with the reaction will be:
(1) -1.74 kcals (2) 1.74 kcals
(3) 0.76 kcals (4) 0.12 kcals
11. Reaction A and reaction B have K'eq values of 10 and 100, respectively. Which of the following statement is correct with respect to ΔG'?
(1) ΔG' of A= ΔG' of B
(2) ΔG' of A ≈ ΔG' of B
(3) ΔG' of B > ΔG' of A
(4) ΔG' of A > ΔG' of B
12. Which one of the following is an expression of the van't Hoff equation?
(1) $\ln K = -\Delta H_0/RT + \Delta S_0/R$
(2) $\Delta H(T_2) = \Delta H(T_1) + \Delta Cp(T_2 - T_1)$
(3) $\Delta G_0 = \Delta H_0 - T\Delta S_0$
(4) $\Delta U = q + w$

13. The equilibrium constant ((Keq) for the reaction S↔ P is 5. Suppose we have a mixture of [S] = 2 x 10^{-4} M and [P] = 3 x 10^{-4} M. In which direction will the reaction proceed on addition of appropriate enzyme?
    (1) Proceeds in a forward direction
    (2) Proceeds in a reverse direction
    (3) Proceeds in both the directions
    (4) Proceeds sometimes in forward and sometimes in reverse direction
14. A decrease in entropy in a reaction (+ ΔS_{system}) can be overcome by
    (1) A decrease in entropy in the surroundings ($-\Delta S_{surrounding}$).
    (2) If the temperature of the reaction is lower than the ratio of $\Delta H/\Delta S$.
    (3) If the temperature of the reaction is greater than the ratio of $\Delta H/\Delta S$.
    (4) Increase in free energy
15. Hydrolysis of ATP over ADP and AMP generates highest energy because
    (1) ATP on hydrolysis generates thermodynamically stable structure
    (2) ATP is highly unstable
    (3) Hydrolysis of ATP is pH dependent
    (4) Hydrolysis of ADP and AMP do not generate thermodynamically stable structure
16. Considering the equation $\Delta G^0=\Delta H^0 - \Delta S^0$which one of the following statements is NOT CORRECT?
    (1) When ΔG^0 is negative, the reaction is exergonic
    (2) When ΔG^0 is negative, the reaction can occur spontaneously
    (3) When ΔS^0 is negative, the molecular disorder decreases during the reaction
    (4) When ΔH^0 is negative, the reaction is endothermic
17. During a cyclic process, which one of the following is NOT always zero?
    (1) Enthalpy change
    (2) Entropy change
    (3) Internal energy change
    (4) Work done by the system
18. 8M urea solution became cold when it was prepared by dissolving an appropriate amount of urea in water at room temperature. This is because the dissolution of urea is
    (1) exothermic and exergonic
    (2) exothermic and endergonic
    (3) endothermic and exergonic
    (4) endothermic and endergonic
19. In which of the following case does the entropy decrease?
    (1) Polymerization
    (2) Melting of ice
    (3) Boiling of water
    (4) Dissolution of sodium chloride in water
20. Which of the following statements is correct regarding the entropy change during protein folding?
    (1) Entropy of the protein chain increases while that of the solvent decreases
    (2) Entropy of the protein chain decreases while that of the solvent increase
    (3) Both the entropies of the protein chain and the solvent increase
    (4) Both the entropies of the protein chain and the solvent decrease
21. Sometimes reactions may not easily take place even though the standard free energy change is highly negative. Which one of the following is a possible explanation?
    (1) The statement itself is false, therefore needs no explanation
    (2) The reverse reaction is very fast as compared to forward reaction
    (3) The reaction is highly endothermic
    (4) The free energy of activation is very high
22. Life in a different planet has evolved to use a reaction
    $$A + B \rightarrow C$$
    This reaction releases a lot of energy that sustains life. A and B are both naturally abundant and are found in air. What is the nature of this reaction $A + B \rightarrow C$ in nature for life to be sustainable?
    (1) The reaction should be thermodynamically favourable but kinetically hindered
    (2) The reaction should be kinetically favourable but thermodynamically hindered
    (3) The reaction should be thermodynamically and kinetically favourable
    (4) The reaction should be thermodynamically and kinetically hindered
23. Which among the following statements about living systems is not correct?
    (1) They can grow and divide.
    (2) They can evolve.
    (3) They constitute a thermodynamically closed system.
    (4) They can convert one form energy into another.

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1

BIOCHEMISTRY

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Section A: Atoms, Bonds and Interactions

1. Consider the following statements,
A. Isotopes differ in the number of neutrons but have same number of protons
B. Hydrogen, Deuterium and Tritium differ in the number of neutrons and atomic mass
C. Tritium is radioactive and decays to Hydrogen
D. Carbon-14 is radioactive and decays to Nitrogen-14
E. Radioisotopes have stable nucleus

Pick the combination with ALL correct statements
(1) A, B and D (2) B, D and E
(3) A, C and D (4) A, C and E

2. Consider the following statements,
A. When non-polar substance are added in water there is negative change in free energy
B. The interaction between histone proteins and DNA is predominantly electrostatic
C. By knowing the bond energies, it is not possible to deduce whether the bond is covalent or hydrogen bond
D. Hydrophobic interactions are driving force for folding of globular protein.

Pick the combination with correct statements.
(1) A and B (2) B and C
(3) C and D (4) B and D

3. Myoglobin protein in presence of 0.1 M NaCl solution was heated and the observed T_m was 50°C. When the same myoglobin protein solution in 0.5 M NaCl was heated, the observed T_m was 60°C. What is the most probable reason for this increase in T_m?
(1) Hydrophobic interaction is increased and electrostatic repulsion is decreased.
(2) Hydrophobic interaction is decreased and electrostatic repulsion is increased.
(3) Hydrogen-bonding is increased and hydrophobic interactions decreased.
(4) Electrostatic attractive forces and van der Waals interaction is increased

4. Match the following bonds with their suitable occurrence in biological system

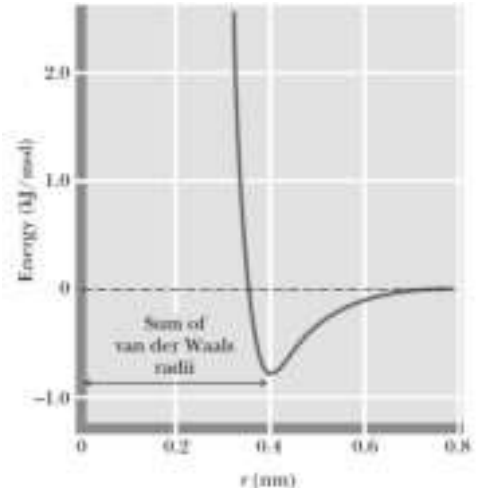
(a)	Hydrogen bond	(i)	Any two atoms in contact
(b)	Van der walls forces	(ii)	Peripheral proteins
(c)	Covalent bond	(iii)	Polypeptide chain
(d)	Ionic bond	(iv)	Double stranded DNA

(1) (a)-(iv), (b)-(iii), (c)-(ii), (d)-(i)
(2) (a)-(ii), (b)-(i), (c)-(iii), (d)- (iv)
(3) (a)-(i), (b)-(iv), (c)-(ii), (d)- (iii)
(4) (a)-(iv), (b)-(i), (c)-(iii), (d)-(ii)

5. Which of the following statement for Vanderwaals interactions?
A. They are formed only atoms of non-polar molecules
B. They are major stabilizing interactions in proteins
C. They are non-specific and weakest among interactions
D. They decrease when the atoms are brought closer or taken away from Vanderwaals contact distance

Which statement are TRUE for Vanderwaals interactions?
(1) A and C (2) B and C
(3) C and D (4) B and D

6. Van der Waals forces are the result of induced electrical interactions between closely approaching atoms or molecules as their negatively-charged electron clouds fluctuate instantaneously in time. These fluctuations allow attractions to occur between the positively charged nuclei and the electrons of nearby atoms. The van der Waals interaction energy profile as a function of the distance, *r,* between the centers of two atoms is shown in diagram below. The energy can be calculated using the empirical equation $U= B/r^{12} - A/r^6$.



Consider the following statements:
A. When two atoms approach each other so closely that their electron clouds interpenetrate, strong repulsion occurs. Such *repulsive* van der Waals forces follow an inverse 12th-power dependence on *r* ($1/r^{12}$),
B. Van der Waals interactions include dipole–dipole interactions, whose interaction energies decrease as $1/r^3$; dipole-induced dipole interactions, which fall off as $1/r^5$; and induced dipole-induced dipole interactions, often called London dispersion forces, which diminish as $1/r^6$.

C. Between the repulsive and attractive domains lies a low point in the potential curve. This low point defines the distance known as the van der Waals contact distance, which is the interatomic distance that results if only van der Waals forces hold two atoms together and at this distance the interaction is strongest.
D. At best, van der Waals interactions are weak and individually contribute 0.4 to 4.0 kcal/mol of stabilization energy.
E. Vander wall interactions are formed only in non-polar environments

Which of the following statement is true?
(1) A, B and C (2) B, C and D
(3) C, D and E (4) D, A and E

7. Consider the following cases of hydrogen bonding between hydrogen donor (represented by solid line) and hydrogen acceptor (represented by dotted line)

Donor Acceptor
A. O-H---------O
B. O-H---------N
C. N-H---------O
D. N-H---------N

Arrange the following possible hydrogen bonds in decreasing order of strength?
(1) A>B>C>D (2) B>A>D>C
(3) A>C>D>B (4) B>D>C>A

8. Hydrophobic amino acids are prevalent in transmembrane regions of membrane embedded proteins because
(1) Hydrophobic amino acids destabilize the membrane bilayer and increase
membrane fluidity
(2) Phospholipid tails are hydrophobic and therefore membrane embedded regions can be stabilized through hydrophobic interactions
(3) The side chains of hydrophobic amino acids interact covalently with
phospholipids
(4) It is just a random occurrence originated from heavy bias of hydrophobic

9. Non-covalent bonds are not as strong as covalent bonds, but they are important in the stabilization of molecules. In contrast to covalent bonds, non-covalent bonds do not share electrons.

Match the following bonds with their approximate energies:

(a)	Hydrogen bond	(i)	21 KJ
(b)	Van der walls forces	(ii)	15 KJ
(c)	Ionic interaction	(iii)	10 KJ
(d)	Hydrophobic interactions	(iv)	5 KJ

(1) (a)-(iv), (b)-(iii), (c)-(ii), (d)-(i)
(2) (a)-(ii), (b)-(i), (c)-(iii), (d)- (iv)
(3) (a)-(i), (b)-(iv), (c)-(ii), (d)- (iii)
(4) (a)-(iv), (b)-(i), (c)-(iii), (d)-(ii)

10. Many isotopes, however, are unstable; they undergo radioactive decay, a process that involves the emission from the radioactive nuclei of subatomic particles such as helium nuclei (α particles), electrons (β particles), and/or photons (γ radiation). Radioactive nuclei emit characteristic radiation with fixed life as shown in table below

Radioisotope	Radiation Type	Half-Life
A. ^{3}H	(i) weak β	I. 12.31 years
B. ^{14}C		II. 5715 years
C. ^{22}Na	(ii) γ rays	III. 2.60 years
D. ^{32}P	(iii) strong β	IV. 14.28 days

Which of the following is correct match?
(1) A-(i)-III; B-(i)-II, C-(ii)-III, D-(iii)-IV
(2) A-(i)-IV; B-(ii)-II, C-(ii)-III, D-(iii)-I
(3) A-(iii)-III; B-(i)-I, C-(ii)-II, D-(iii)-IV
(4) A-(iii)-I; B-(ii)-IV, C-(ii)-III, D-(iii)-III

Section B: pH and Buffer

1. The pH of 10^{-8} M solution of HCl will be
[Given log of 10^{-8} = - 8; log 1.1 = 0.04]
(1) 7.96 (2) 7
(3) 6.96 (4) 7.04

2. 10 mM Phosphate buffer (pH 9.00) is diluted one million times with distilled water (pH 7.00). pH of this diluted buffer is:
(1) 4.00 (2) 7.04
(3) 8.00 (4) 6.96

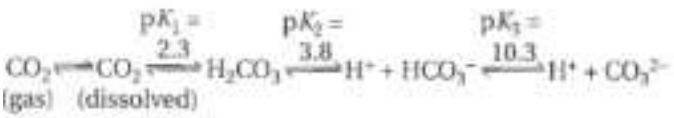
(Help: log10 10x = x; log10 1.10 = 0.04; log10 1.01 = 0.004)

3. In this question, "up" means higher than and "down" means lower than the normal values of pH = 7.4, [HCO_3^-] = 24 mM, and pCO_2 = 40 mm Hg.

In partially compensated metabolic alkalosis:

	pH	[HCO^{3-}]	pCO_2
(1)	Up	Up	Down
(2)	Down	Up	Up
(3)	Up	Up	Up
(4)	Down	Up	Down

4. During an all-out sprint, muscles metabolize glucose anaerobically, producing a high concentration of lactic acid, which lowers the pH of the blood and of the cytosol and contributes to the fatigue sprinters experience well before their fuel reserves are exhausted. The main blood buffer against pH changes is the bicarbonate/CO_2 system.



What would you advise sprinters to improve their performance?

(1) to hold their breath for a minute immediately before the race

(2) to breathe rapidly for a minute immediately before the race

(3) to hold their breath for a minute immediately after the race

(4) to breathe rapidly for a minute immediately after the race

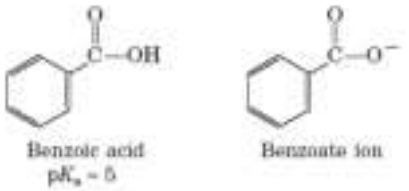
5. As shown above, phosphoric acid has three ionizable protons, with the pK_a values indicated. The buffering capacity of phosphoric acid is LEAST at pH:

(1) 2.1 (2) 4.6

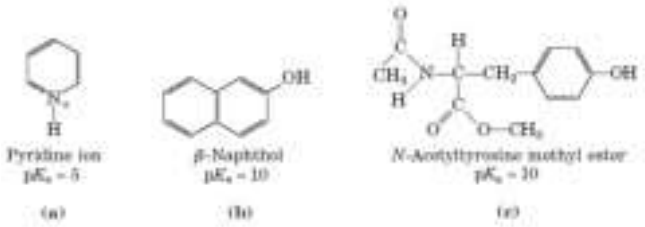
(3) 6.8 (4) 7.4

6. The strongly polar hydrogen-bonding properties of water make it an excellent solvent for ionic (charged) species. By contrast, nonionized, nonpolar organic molecules, such as benzene, are relatively insoluble in water. In principle, the aqueous solubility of an organic acid or base can be increased by converting the molecules to charged species. For example, the solubility of benzoic acid in water is low.

The addition of sodium bicarbonate to a mixture of water and benzoic acid raises the pH and deprotonates the benzoic acid to form benzoate ion, which is quite soluble in water.



Consider the following compounds in respect to solubility in an aqueous solution of 0.1 M NaOH or 0.1 M HCl. (The dissociable proton in (c) is that of the OOH group.)



A. Pyridine is ionic in its protonated form and therefore more soluble at the lower pH, in 0.1 M HCl.

B. β-Naphthol is ionic when *de*protonated and thus more soluble at the higher pH, in 0.1 M NaOH.

C. *N*-Acetyl tyrosine methyl ester is ionic when *de*protonated and thus more soluble in 0.1 M N HCl.

Which of the following statement is/are true?

(1) A only (2) A and B

(3) B and C (4) A, B and C

7. What would be the fraction of histidine that has its imidazole side chain deprotonated at pH 7? (The pKa values for histidine are pK_1 =1.8 pK_2 (imidazole) = 6 and pK_3= 9.2)

(1) 1 % (2) 10 %

(3) 90 % (4) 99 %

8. During the fermentation of wine, a buffer system consisting of tartaric acid and potassium hydrogen tartrate is produced by a biochemical reaction.

Assuming that at some time the concentration of potassium hydrogen tartrate is twice that of tartaric acid, calculate the pH of the wine. The pKa of tartaric acid is 2.96.

(1) 2.96 (2) 2.66

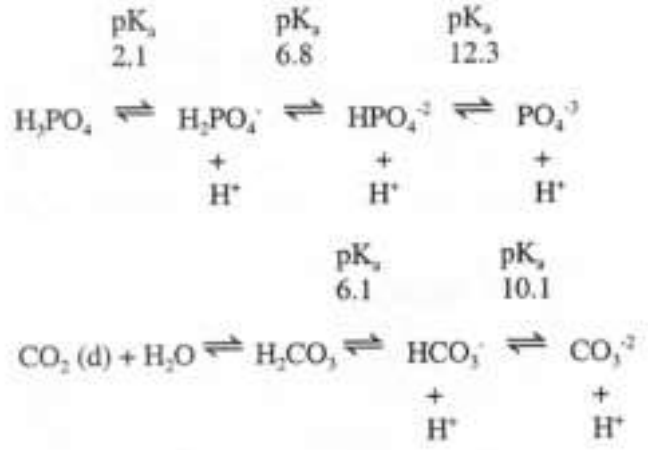
(3) 3.26 (4) 4.96

9. Consider the following statements regarding pH and Buffers:
A. pH is the negative log of $[H^+]$. A low pH characterizes an acidic solution, and a high pH denotes a basic solution.
B. The strength of weak acids is expressed by p*K*a, the negative log of the acid dissociation constant.
C. Strong acids have high p*K*a values and weak acids have low p*K*a values.
D. Buffers resist a change in pH when protons are produced or consumed. Maximum buffering capacity occurs ± 1 pH unit on either side of p*K*a. Physiologic buffers include bicarbonate, orthophosphate, and proteins.

Which of the following statements are true?
(1) A and C (2) C and D
(3) A, B and D (4) A, B and C

10. The pH of blood of a healthy person is maintained at 7.40 ± 0.05, Assuming that this pH is maintained entirely by the bicarbonate buffer (pKa_1, and pKa_2 of carbonic acid are 6.1 and 10.3, respectively), the molar ratio of [bicarbonate]/ [carbonic acid] in the blood is
(1) 0.05 (2) 1
(3) 10 (4) 20

11. In a venous blood sample, the ratio of $[HPO_4^{-2}]/[H_2PO_4^-]$ =2.



In this same blood sample, what would be the ratio of $[HCO_3^-]/[CO_2(d)]$?
(1) 20:1 (2) 15:1
(3) 10:1 (4) 5:1

12. Consider the following statements for buffer
A. The ability of a buffer to resist pH changes with added acid or base is directly proportional to the total concentration of the conjugate acid–base pair, [HA] = $[A^-]$.
B. Maximal buffering by weak acid is when pH = pKa and is in its useful buffer range within 1 pH unit of its pKa.
C. The lactate and acetate ions that are components of most biological fluids are important for maintaining physiological pH (pH=7) because they have pKa in this range.
D. The pK's of two closely associated acid–base groups in polyprotic acid are independent.

Which of the following statements are true?
(1) A and B (2) C and D
(3) A, C and D (4) B, C and D

Section C: Molarity/Colligative Property/Rate Of Reaction

1. If the nucleus of diploid somatic cell has 2n=48 chromosomes. Calculate moles of chromosome in diploid somatic cell [1 mole = 6 x 10^{23} molecules].
(1) 8 X 10^{-23} (2) 48 X 10^{-23}
(3) 8 X 10^{23} (4) 2.88 X 10^{-21}

2. What will be the required volumes of 1N HCl and 4N NaOH to prepare one litre solution of pH 7?
(1) 500 ml; 500 ml (2) 800 ml; 200 ml
(3) 600 ml; 400 ml (4) 200 ml; 800 ml

3. Calculate the molarity of enzyme alcohol dehydrogenase solution with concentration of 1mg/ml (Molecular weight: 80 Kd)
(1) 12.5 M (2) 12.5 mM
(3) 12.5 µM (4) 80 mM

4. In a polymerase chain reaction, the concentration of each primer needs to be 10 µM. If the primer is 20 nucleotides long and average molecular weight of each nucleotide is 333Da, what would be the concentration in µg/ml?
(1) 660 (2) 66·6
(3) 6·6 (4) 0·66

5. Suppose the major solutes in intact lysosomes are KCl (0.1 M) and NaCl (0.03 M). When isolating lysosomes, what concentration of sucrose is required in the extracting solution at room temperature (25 ^{0}C) to prevent swelling and lysis?
(1) 0.13 M (2) 0.26 M
(3) 0. 07 M (4) 0.31 M