MEGA Solution Series

Volume V

Biotechnology Biochemistry Microbiology

covers following

- **Mathematical Biology**

Editor
Kar Debasish

Contents

Mathematical Biology

Questions

Answer Keys

Explanations

CHAPTER 01

Analytical Chemistry

UNIT 1: pH AND BUFFER

1. 20.0 cm^3 of 1.00 M HNO_2 and 40.0 cm^3 of 0.500 M $NaNO_2$ are mixed. What is the pH of the resulting solution? pK_a of nitrous acid is 3.34

(*a*) 1.34 (*b*) 2.34 (*c*) 3.34 (*d*) 4.34

2. Calculate the pH of a solution prepared by mixing 15.0 mL of 0.100 M NaOH and 30.0 mL of 0.100 M benzoic acid soluion. (Benzoic acid is monoprotic; its dissociation constant is 6.46×10^{-5}.)

(*a*) 4.19 (*b*) 3.19 (*c*) 2.19 (*d*) 1.19

3. Calculate the pH of a solution prepared by mixing 5.00 mL of 0.500 M NaOH and 20.0 mL of 0.500 M benzoic acid solution. (Benzoic acid is monoprotic: its ionization constant is 6.46×10^{-5}.)

(*a*) 2.7 (*b*) 3.7 (*c*) 4.7 (*d*) 5.7

4. How many grams of NH4Cl need to be added to 1.50 L of 0.400 M ammonia in order to make a buffer solution with pH of 8.58? K_b for ammonia is 1.77×10^{-5}

(*a*) 4.86 M (*b*) 3.86 M
(*c*) 2.86 M (*d*) 1.86 M

5. How many grams of dry NH_4Cl need to be added to 2.40 L of a 0.800 M solution of ammonia to prepare a buffer solution that has a pH of 8.90? K_b for ammonia is 1.77×10^{-5}.

(*a*) 129 gm (*b*) 229 gm
(*c*) 329 gm (*d*) 429 gm

6. Determine the pH of the buffer made by mixing 0.030 mol HCl with 0.050 mol CH_3COONa in 2.00 L of solution. The K_a of acetic acid is 1.77×10^{-5}.

(*a*) 2.64 (*b*) 4.28 (*c*) 4.58 (*d*) 8.32

7. Determine the pH of the solution after the addition of 133 mL of 0.027 M nitric acid (HNO_3) to 172 mL of 0.057 M sodium hydrogen citrate ($Na_2C_3H_5O(COOH)(COO)_2$)

(*a*) 2 (*b*) 5 (*c*) 10 (*d*) 15

8. 1.00 L of a buffer with a pH of 4.30 contains 0.33 M of sodium benzoate and 0.26 M of benzoic acid. What is the pH in the buffer solution after the addition of 0.058 mol of HCl to a final volume of 1.6 L?

(*a*) 0.85 (*b*) 3.80 (*c*) 4.40 (*d*) 4.15

9. A buffer solution contains 5.00 mL of 2.00 M acetic acid, 45.0 mL water and 2.05 g sodium acetate. Predict the pH of the buffer solution.

(*a*) 3.15 (*b*) 5.15 (*c*) 5.65 (*d*) 8.35

10. We have available a 0.100 M acetic acid solution as well as a 0.100 M sodium acetic solution. What volume of each would be required to produce 1.00 L of a buffer with pH 4.000? Assume that the volumes of the two solutions are additive. (pK_a = 4.752)

(*a*) 850 ml (*b*) 720 ml
(*c*) 410 ml (*d*) 350 ml

11. Which of the following buffer systems would be the best choice to create a buffer of pH = 7.20?

(*a*) CH_3COOH & CH_3COOK
(*b*) $HClO_2$ & $KClO_2$
(*c*) NH_3 & NH_4Cl
(*d*) HClO & KClO

12. What is the $[A^-]/[HA]$ ratio when a weak acid is in a solution with the pH one unit below its pK_a?

(*a*) 1/2 (*b*) 1/5
(*c*) 1/10 (*d*) 1/100

13. What is the pH of the resulting solution if 40.0 mL of 0.432 M methylamine, CH_3NH_2, is added to 15.0 mL of 0.234 M HCl? Assume that the volumes of the solutions are additive. pK_a = 10.66 for $CH_3NH_3^+$

(*a*) 7.15 (*b*) 8.35 (*c*) 10.45 (*d*) 11.25

14. Calculate the pH after 0.020 mol of HCl is added to 1.00 L of 0.10 M $NaC_3H_5O_2$. $K_a = 1.3 \times 10^{-5}$.

(*a*) 5.5 (*b*) 3.2 (*c*) 8.5 (*d*) 10.7

15. A buffer with a pH of 4.31 contains 0.31 M of sodium benzoate and 0.24 M of benzoic acid. What is the concentration of $[H^+]$ in the solution after the addition of 0.050 mol of HCl to a final volume of 1.3 L? Assume that any contribution of HCl to the volume is negligible.

(*a*) 0.00065 M (*b*) 0.000025 M
(*c*) 0.0065 M (*d*) 0.000065 M

16. What would the concentration of sodium formate (NaCOOH) be in 0.00750 M formate buffer at pH 4.358?

(*a*) 4.358 (*b*) 2.328
(*c*) 6.152 (*d*) 5.354

17. In 1.00 L of solution, 0.529 mole of HNO_2 is added to 0.246 mole of NaOH. (Nitrous acid has a Ka of 4.0×10^{-4}.) What is the final pH?

(*a*) 1.32 (*b*) 5.45 (*c*) 2.30 (*d*) 3.34

18. You desire to create a solution with a pH of 3.26. If you add 0.577 moles of HF to 1.00 L of solution, how many moles of NaF should you add?

(*a*) 0.76 mol (*b*) 0.24 ml
(*c*) 0.5 mol (*d*) 0.38 mol

19. If you begin with 48.2 mL of a 0.171 M solution of HNO_2, how many grams of $NaNO_2$ would you have to add to the solution for a pH of 3.32?

(*a*) 0.27 gm (*b*) 0.47 gm
(*c*) 0.67 gm (*d*) 0.87 gm

20. Calculate the ratio of the concentration of acetic acid and acetate required in a buffer system at a pH of 4.208 (the pK_a of acetic acid equals 4.752).

(*a*) 3.5 : 1.0 (*b*) 3.5 : 1.5
(*c*) 2.0 : 1.0 (*d*) 3.5 : 4.0

21. What volume of 6.00 M NaOH must be added to 0.250 L of 0.300 M HNO_2 to prepare a pH = 4.00 buffer?

(*a*) 1 ml (*b*) 2 ml (*c*) 5 ml (*d*) 10 ml

22. If an acetate buffer solution was going to be prepared by neutralizing $HC_2H_3O_2$ with 0.10 M NaOH, what volume (in mL) of 0.10 M NaOH would need to be added to 10.0 mL of 0.10 M $HC_2H_3O_2$ to prepare a solution with pH = 5.50?

(*a*) 1 ml (*b*) 2 ml (*c*) 7.5 ml (*d*) 8.5 ml

23. A beaker with 175 mL of an acetic acid buffer with a pH of 5.000 is sitting on a benchtop. The total molarity of acid and conjugate base in this buffer is 0.100 M. A student adds 8.40 mL of a 0.300 M HCl solution to the beaker. What is the new pH? The pK_a of acetic acid is 4.752.

(*a*) 2.4 (*b*) 3.4 (*c*) 4.4 (*d*) 4.7

24. 200.0 mL of an acetate/acetic acid buffer is 0.100 M in total molarity and has a pH of 5.000. After 6.30 mL of 0.490 M HCl is added, what is the new pH?

(*a*) 4.7 (*b*) 3.4 (*c*) 8.4 (*d*) 7.2

25. We desire to make a pH 5.000 buffer and we choose a weak acid (let's call it HA) with a pK_a of 4.700. Starting with 0.100 M each HA and NaA, we desire to make 100. mL buffer solution. What amount in ml you require to make the buffer?

(*a*) 60.0 mL of NaA and 40.0 mL of HA
(*b*) 56.7 mL of NaA and 43.3 mL of HA
(*c*) 66.7 mL of NaA and 33.3 mL of HA
(*d*) 62.4 mL of NaA and 37.6 mL of HA

26. Calculate the volume (in mL) of 0.170 M NaOH that must be added to 311 mL of 0.0485 M HA (a generic weak acid) to give the solution a pH of 7.55. The pK_a of HA = 7.18.

(*a*) 42.8 ml (*b*) 62.2 ml
(*c*) 52.4 ml (*d*) 68.5 ml

27. What mass of HCl would need to be added to a 250. mL solution containing 0.500 M $NaC_2H_3O_2$ and 0.500 M $HC_2H_3O_2$, to make the pH = 4.25? K_a of $HC_2H_3O_2$ is 1.77×10^{-5}.

(*a*) 2.30 gm (*b*) 1.48 gm
(*c*) 2.38 gm (*d*) 4.50 gm

28. What mass of HCl would need to be added to a 250 mL solution containing 0.500 M $NaC_2H_3O_2$ and 0.500 M $HC_2H_3O_2$, to make the pH = 4.25? K_a of $HC_2H_3O_2$ is 1.77×10^{-5}.

(*a*) 2.60 gm (*b*) 1.42 gm
(*c*) 2.36 gm (*d*) 4.50 gm

29. How many mL of 0.75 M HCl must be added to 120 mL of 0.90 M sodium formate to make a buffer of pH = 4.00? pK_a of formic acid = 3.75

(*a*) 51.8 ml (*b*) 43.2 ml
(*c*) 37.8 ml (*d*) 22.2 ml

30. You need to prepare a buffer solution of pH 4.178 from 25.0 mL of 0.282 M solution of a sodium salt of a weak acid, NaA where the pK_a of the weak acid HA is 4.270. What volume of 0.329 M HCl would you need to add?

(*a*) 8.42 ml (*b*) 9.13 ml
(*c*) 11.84 ml (*d*) 12.05 ml

31. There are two solutions namely A and B. They differ in pH by 3 unit. This means

(*a*) Solution A has 3 times $[H^+]$ than solution B
(*b*) Solution A has 30 times $[H^+]$ than solution B
(*c*) Solution A has 300 times $[H^+]$ than solution B
(*d*) Solution A has 1000 times $[H^+]$ than solution B

32. Let assume that the concentration of H^+ in a solution is 10^{-3} M, at 25°C. Then what will be the concentration of OH-?

(*a*) 10^{-11} M (*b*) 10^{-3} M
(*c*) 2×10^{-11} M (*d*) 10^{11} M

33. If pH of the solution of NaOH is 12.0. What will be the pH of H2SO4 solution of same molarity?

(*a*) 12.0 (*b*) 7.0 (*c*) 3.4 (*d*) 1.7

34. What is the concentration of OH^- in a solution with a H^+ concentration of 1.3×10^{-4} M?

(*a*) 7.7×10^{-10} M (*b*) 7.7×10^{-9} M
(*c*) 7.7×10^{-11} M (*d*) 7.7×10^{-12} M

35. If pK_b for fluoride at 25ºc is 10.83. What will be the ionization constant of hydrofluoric acid in water at this temperature?
(*a*) 3.52×10^{-3} (*b*) 6.75×10^{-4}
(*c*) 5.38×10^{-2} (*d*) 1.74×10^{-5}

36. The pK_a of acetic acid is 4.76. What will be the pH of a mixture of 0.10 M acetic acid and 0.20 M sodium acetate?
(*a*) 7.1 (*b*) 4.1 (*c*) 5.1 (*d*) 6.1

UNIT 2: LABORATORY CALCULATION-I

37. You need to make a 1 : 5 dilution of a solution. You need 10 ml of the diluted solution. How much diluent should you use?
(*a*) 2 ml (*b*) 3.5 ml (*c*) 6.5 ml (*d*) 8 ml

38. How much NaCl would you require to prepare 500 ml of a 10% NaCl solution?
(*a*) 50 gm (*b*) 40 gm (*c*) 45 gm (*d*) 30 gm

39. If you have DNA with a concentration of 2 µg/µl, how much DNA (in µl) must be added to make a 20 µl solution with a DNA concentration of 1 µg/µl?
(*a*) 40 µl (*b*) 30 µl (*c*) 20 µl (*d*) 10 µl

40. You have a 10x TBE buffer. To run a gel, you need 500 ml of a 2x solution of TBE. How do you make a 500 ml solution of 2x TBE buffer from the 10x buffer?
(*a*) 100 ml (*b*) 200 ml (*c*) 300 ml (*d*) 400 ml

41. You want to make a 0.5% agarose gel. How much agarose (in grams) do you need to make up a 50 ml gel solution?
(*a*) 0.25 gm (*b*) 0.45 gm
(*c*) 0.50 gm (*d*) 1 gm

42. What is the DNA concentration of a 50 µl solution which contains 10 µl of DNA at a concentration of 4 µg/µl?
(*a*) 0.5 µg/µl (*b*) 0.8 µg/µl
(*c*) 0.3 µg/µl (*d*) 1.2 µg/µl

43. How much diluent would you need to make a 3x TBE buffer from a 12x TBE buffer for a total volume of 200 ml?
(*a*) 50 ml (*b*) 100 ml
(*c*) 150 ml (*d*) 180 ml

44. If 10x TBE contains 0.89 M Tris-borate, 0.89 M Boric acid, and 0.02 M EDTA, what is the Molar concentration of Tris-borate in 100 ml of 1x TBE?
(*a*) 0.09 M (*b*) 0.07 M
(*c*) 0.05 M (*d*) 0.01 M

45. How many ml of 0.5 M EDTA are required to make 100 ml of a 0.1 M EDTA solution?
(*a*) 5 ml (*b*) 10 ml (*c*) 15 ml (*d*) 20 ml

46. If a solution of DNA is 3 mg/ml, 0.5 mg of DNA would be contained in how many ml?
(*a*) 0.32 ml (*b*) 0.17 ml
(*c*) 0.14 ml (*d*) 0.10 ml

47. If you have a 5x stock solution, how much of this stock would be needed to make 100 ml of a 1x solution? 10 ml of a 1x solution?
(*a*) For 100 ml: 10 ml of 5X and For 10 ml: 2 ml of 5X
(*b*) For 100 ml: 10 ml of 5X and For 10 ml: 5 ml of 5X
(*c*) For 100 ml: 20 ml of 5X and For 10 ml: 2 ml of 5X
(*d*) For 100 ml: 30 ml of 5X and For 10 ml: 5 ml of 5X

48. How many grams of agarose are needed to make 100 ml of a 2% agarose solution?
(*a*) 1 gm (*b*) 1.2 gm (*c*) 2 gm (*d*) 2.4 gm

49. How many ml of the detergent Nonidet P-40 would be used to make 43 ml of a 7% detergent solution?
(*a*) 1.25 ml (*b*) 2.75 ml
(*c*) 3 ml (*d*) 5.25 ml

50. An extraction buffer for DNA is stored as a 15x stock solution. How much of this stock solution would be required to make 7.5 ml of a 1x working solution? a 0.5x solution?
(*a*) 1X: 0.25 ml and 0.5X: 0.5 ml
(*b*) 1X: 0.25 ml and 0.5X: 0.5 ml
(*c*) 1X: 0.75 ml and 0.5X: 1.50 ml
(*d*) 1X: 0.5 ml and 0.5X: 0.25 ml

51. Given the following stock solutions: 1 M Tris, 0.5 M EDTA, 4 M NaCl, do the calculations necessary to make 1 L of a solution containing 100 mM Tris, 100 mM EDTA, 250 mM NaCl. Estimate the amount of diluent required to make it 1L.
(*a*) 637.50 ml (*b*) 455.25 ml
(*c*) 320.75 ml (*d*) 132.50 ml

52. The following stock solutions are available to make a protein extraction buffer: 100% Nonidet P-40, 1 M Tris-Cl, and 0.5 M EDTA. What quantity of the original stocks will be needed to make 250 ml of buffer with the following final concentrations: 0.5% Nonidet, 150 mM Tris-Cl, and 10 mM EDTA? Estimate the amount of diluent to make it 250 ml.
(*a*) 637.50 ml (*b*) 206.25 ml
(*c*) 186.75 ml (*d*) 132.50 ml

53. If you dilute 175 mL of a 1.6 M solution of LiCl to 1.0 L, determine the new concentration of the solution.

(*a*) 0.12 mM (*b*) 0.24 M
(*c*) 0.28 M (*d*) 0.76 mM

54. You need to make 10.0 L of 1.2 M KNO_3. What molarity would the potassium nitrate solution need to be if you were to use only 2.5 L of it?

(*a*) 1.2 M (*b*) 2.4 M (*c*) 3.6 M (*d*) 4.8 M

55. How many milliliters of 5.0 M copper(II) sulfate solution must be added to 160 mL of water to achieve a 0.30 M copper(II) sulfate solution?

(*a*) 10 ml (*b*) 20 ml (*c*) 25 ml (*d*) 40 ml

56. What volume of 4.50 M HCl can be made by mixing 5.65 M HCl with 250.0 mL of 3.55 M HCl?

(*a*) 352.5 mL (*b*) 456.5 mL
(*c*) 485.5 mL (*d*) 665.5 mL

57. A 40.0 mL volume of 1.80 M $Fe(NO_3)_3$ is mixed with 21.5 mL of 0.808M $Fe(NO_3)_3$ solution. Calculate the molar concentration of the final solution.

(*a*) 0.85 M (*b*) 1.15 M
(*c*) 1.45 M (*d*) 3.75 M

58. To 2.00 L of 0.445 M HCl, you add 3.88 L of a second HCl solution of an unknown concentration. The resulting solution is 0.974 M. Assuming the volumes are additive, calculate the molarity of the second HCl solution.

(*a*) 0.75 M (*b*) 1.0 M
(*c*) 1.25 M (*d*) 1.75 M

59. To what volume should you dilute 133 mL of an 7.90 M $CuCl_2$ solution so that 51.5 mL of the diluted solution contains 4.49 g $CuCl_2$?

(*a*) 1000 ml (*b*) 1200 ml
(*c*) 1452 ml (*d*) 1620 ml

60. If volumes are additive and 95.0 mL of 0.55 M KBr is mixed with 165.0 mL of a $BaBr_2$ solution to give a new solution in which $[Br^-]$ is 0.65 M, what is the concentration of the $BaBr_2$ used to make the new solution?

(*a*) 0.15 M (*b*) 0.25 M
(*c*) 0.35 M (*d*) 0.65 M

61. 1.00 L of a solution is prepared by dissolving 125.6 g of NaF in it. If I took 180 mL of that solution and diluted it to 500 mL, determine the molarity of the resulting solution.

(*a*) 0.65 M (*b*) 0.78 M
(*c*) 1.08 M (*d*) 2.84 M

62. What is the molar concentration of chloride ions in a solution prepared by mixing 100.0 mL of 2.0 M KCl with 50.0 mL of a 1.50 M $CaCl_2$ solution?

(Warning: there's a complication in the solution. It has to do with the $CaCl_2$.)

(*a*) 2.13 M (*b*) 2.33 M
(*c*) 3.42 M (*d*) 3.84 M

UNIT 3: LABORATORY CALCULATION–II

63. Sea water contains roughly 28.0 g of NaCl per liter. What is the molarity of sodium chloride in sea water?

(*a*) 0.28 M (*b*) 0.34 M
(*c*) 0.44 M (*d*) 0.48 M

64. What is the molarity of 245.0 g of H_2SO_4 dissolved in 1.000 L of solution?

(*a*) 0.28 M (*b*) 1.34 M
(*c*) 2.44 M (*d*) 2.49 M

65. What is the molarity of 5.30 g of Na_2CO_3 dissolved in 400.0 mL solution?

(*a*) 0.12 M (*b*) 0.34 M
(*c*) 0.44 M (*d*) 0.48 M

66. What is the molarity of 5.00 g of NaOH in 750.0 mL of solution?

(*a*) 0.16 M (*b*) 0.34 M
(*c*) 0.44 M (*d*) 0.48 M

67. How many moles of Na_2CO_3 are there in 10.0 L of 2.00 M solution?

(*a*) 5 mol (*b*) 10 mol
(*c*) 20 mol (*d*) 25 mol

68. How many moles of Na_2CO_3 are in 10.0 mL of a 2.0 M solution?

(*a*) 0.01 mol (*b*) 10 mol
(*c*) 20 mol (*d*) 0.02 mol

69. How many moles of NaCl are contained in 100.0 mL of a 0.200 M solution?

(*a*) 0.01 mol (*b*) 10 mol
(*c*) 20 mol (*d*) 0.02 mol

70. What weight (in grams) of NaCl would be contained in the previous problem?

(*a*) 0.78 gm (*b*) 0.92 gm
(*c*) 1.14 gm (*d*) 1.17 gm

71. What weight (in grams) of H_2SO_4 would be needed to make 750.0 mL of 2.00 M solution?

(*a*) 122 gm (*b*) 132.4 gm
(*c*) 142.2 gm (*d*) 147.1 gm

72. What volume (in mL) of 18.0 M H_2SO_4 is needed to contain 2.45 g H_2SO_4?
(*a*) 1.24 (*b*) 1.39 (*c*) 2.45 (*d*) 3.15

73. What volume (in mL) of 12.0 M HCl is needed to contain 3.00 moles of HCl?
(*a*) 50 ml (*b*) 100 ml
(*c*) 150 ml (*d*) 250 ml

74. How many grams of $Ca(OH)_2$ are needed to make 100.0 mL of 0.250 M solution?
(*a*) 1.15 gm (*b*) 1.35 gm
(*c*) 1.65 gm (*d*) 1.85 gm

75. What is the molarity of a solution made by dissolving 20.0 g of H_3PO_4 in 50.0 mL of solution?
(*a*) 1.52 M (*b*) 2.75 M
(*c*) 3.24 M (*d*) 4.08 M

76. What weight (in grams) of KCl is there in 2.50 liters of 0.500 M KCl solution?
(*a*) 23.6 gm (*b*) 46.4 gm
(*c*) 68.4 gm (*d*) 93.2 gm

77. What is the molarity of a solution containing 12.0 g of NaOH in 250.0 mL of solution?
(*a*) 0.8 M (*b*) 1.2 M (*c*) 1.8 M (*d*) 2.4 M

78. A student placed 11.0 g of glucose ($C_6H_{12}O_6$) in a volumetric flask, added enough water to dissolve the glucose by swirling, then carefully added additional water until the 100. mL mark on the neck of the flask was reached. The flask was then shaken until the solution was uniform. A 20.0 mL sample of this glucose solution was diluted to 0.500L. How many grams of glucose are in 100. mL of the final solution?
(*a*) 0.22 gm (*b*) 0.33 gm
(*c*) 0.44 gm (*d*) 0.55 gm

79. A solution of H_2SO_4 with a molal concentration of 8.010 m has a density of 1.354 g/mL. What is the molar concentration of this solution?
(*a*) 4.28 M (*b*) 4.68 M
(*c*) 6.07 M (*d*) 7.82 M

80. A sulfuric acid solution containing 571.4 g of H_2SO_4 per liter of solution has a density of 1.329 g/cm^3. Calculate the molality of H_2SO_4 in this solution
(*a*) 2.4 m (*b*) 5.3 m (*c*) 7.2 m (*d*) 7.6 m

81. An aqueous solution is prepared by diluting 3.30 mL acetone (d = 0.789 g/mL) with water to a final volume of 75.0 mL. The density of the solution is 0.993 g/mL. What is the molarity of acetone in this solution?
(*a*) 0.2 M (*b*) 0.4 M (*c*) 0.6 M (*d*) 0.8 M

82. Calculate the molality of 15.00 M HCl with a density of 1.0745 g/cm^3
(*a*) 12.68 mol (*b*) 18.26 mol
(*c*) 24.38 mol (*d*) 28.43 mol

83. What is the mass of a sample of a 0.449 molal KBr that contains 2.92 kg of water?
(*a*) 2.85 Kg (*b*) 3.07 Kg
(*c*) 3.42 Kg (*d*) 4.52 Kg

84. A 0.391 m solution of the solute hexane dissolved in the solvent benzene is available. Calculate the mass (g) of the solution that must be taken to obtain 247 g of hexane (C_6H_{14}).
(*a*) 7.58 Kg (*b*) 6.36 Kg
(*c*) 5.84 Kg (*d*) 4.34 Kg

85. Calculate the mass of the solute C_6H_6 and the mass of the solvent tetrahydrofuran that should be added to prepare 1.63 kg of a solution that is 1.42 m.
(*a*) 0. 82 mol (*b*) 1.26 mol
(*c*) 1.42 mol (*d*) 2.36 mol

86. What is the molality of NaCl in an aqueous solution in which the mole fraction of NaCl is 0.100?
(*a*) 4.18 mol (*b*) 4.84 mol
(*c*) 5.64 mol (*d*) 6.16 mol

CHAPTER 02

Biochemistry

UNIT 1: AMINO ACID CHEMISTRY

1. The approximate weight of protein with 900 amino acids residues in a single polypeptide chain is

(*a*) 75 kDa (*b*) 99 kDa
(*c*) 80 kDa (*d*) 60 kDa

2. Probability of occurring similar amino acid sequence in two oligopeptides of length n will be

(*a*) $1/20^n$ (*b*) n^{20}
(*c*) 20^n (*d*) $1/n^{20}$

3. What is the net charge of the following polypeptide Asp-Arg-Trp-Leu-Gly-Val-Ala-Lys-Pro-Met at pH 3?

[pKa of N-terminal = 9.67, pKa of C-terminal = 2.34, pK_R of Asp = 3.65, pK_R of Lys = 10.53, pK_R of Arg = 12.48]

(*a*) +2 (*b*) –2 (*c*) +4 (*d*) –4

4. Cys has pK_1 = 1.96, pK_2 = 10.28, pK_R = 8.18. What will be its isoelectric point (pI)?

(*a*) 6.12 (*b*) 9.23 (*c*) 5.07 (*d*) 6.80

5. The molecular weight of a protein is 30 kDa. The minimal length of mRNA encoding this polypeptide will be close to-

(*a*) 800 (*b*) 900 (*c*) 1000 (*d*) 300

6. What is the amount of protein required to prepare 5 ml of 1 μM solution (Mol. Wt. of protein is 25 kDa)?

(*a*) 125 μg (*b*) 125 ng
(*c*) 250 μg (*d*) 12.5 μg

7. A segment of B-DNA encodes an enzyme of molecular mass 50 kDa. The estimated length of this segment is

(*a*) 400 bp (*b*) 420 bp
(*c*) 4500 bp (*d*) 1365 bp

8. How many different linear tripeptides can be made from three different L-α amino acids using any of the three amino acids at any position with repetition?

(*a*) 45 (*b*) 27 (*c*) 33 (*d*) 28

9. In the above same question, what will be the total number of tripeptides if each of the three amino acids are used only once in the tripeptides?

(*a*) 8 (*b*) 6 (*c*) 12 (*d*) 27

10. The average molecular weight of an amino acid is 110. What will be the weight of a single molecule of a protein having 270 amino acids?

(*a*) 5.2×10^{-20} g/mol. (*b*) 4×10^{-19} g/mol.
(*c*) 5×10^{-19} g/mol. (*d*) 4.9×10^{-19} g/mol.

11. What is the molecular weight of an mRNA that codes for a protein of 75,000 Da?

(*a*) 2,00,000 (*b*) 3,00,000
(*c*) 6,00,000 (*d*) 10,00,000

12. The three pK's of the amino acid aspartate are given here –1.88, 3.65 and 9.60. Which of the following is true in an electrophoresis experiment?

(*a*) Aspartate does not migrate at pH 1.24.
(*b*) Aspartate does not migrate at pH 2.76.
(*c*) Aspartate does not migrate at pH 6.62.
(*d*) Aspartate does not migrate at pH 11.2.

13. Several information are given here for amino acid leucine:-

I. Nonpolar, aliphatic R group.
II. Molecular weight is 131 D.
III. pK_1 is 2.4; pK_2 is 9.6.
IV. Hydropathy index is 3.8.

Based on this information, what is the WRONG statement given here-?

(*a*) leucine acts as an effective buffer at pH range of 0–5.
(*b*) leucine acts as an effective buffer at pH range of 5–7.
(*c*) leucine acts as an effective buffer at pH range of 7–14.
(*d*) leucine does not act as a buffer at any pH.

14. The pK values are given here for some amino acids. Arrange them in increasing order according to their pI.

Glycine (2.34, 9.60); Glutamate (2.19, 4.25, 9.67); Lysine (2.18, 8.95, 10.53); Asparagine (2.02, 8.80); Arginine (2.17, 9.04, 12.48)

(*a*) Glu < Asn < Gly < Lys < Arg
(*b*) Glu < Asn < Gly < Arg < Lys
(*c*) Gly < Glu < Lys < Asn < Arg
(*d*) Arg < Lys < Gly < Asn < Glu

15. An amino-acid has one proton donating group in the side chain (R). The pK–COOH, pK–NH_2 and pK–R values for this amino-acid are 2.19, 9.67 and 4.25, respectively. Which one of the following statements about this amino-acid is CORRECT?

(*a*) Majority of the molecules will have a net charge of –1 at pH of 7.0.

(*b*) Majority of the molecules will have a net charge of 0 at pH of 4.25.

(*c*) All the molecules will have a deprotonated R group at pH of 3.22.

(*d*) During titration with a strong base, deprotonation will start with the R group.

16. Electrophoresis on a paper is affected on the basis of the charge on a peptide at different pH values for separation of small peptides. If 'Z', 'X', 'Y' stands for migration toward the cathode, anode remains stationary respectively; then at the given pH values select the correct direction of migration order of the peptide (Lys-Gly-Ala-Glu).

Sl. No.	Peptide	pH 2.0	pH 4.0	pH 6.0	pH 11.0
I.	Lys-Gly-Ala-Glu	Z	Z	Y	X
II.	Lys-Gly-Ala-Glu	X	Z	Y	X
III.	Lys-Gly-Ala-Glu	Z	X	X	X
IV.	Lys-Gly-Ala-Glu	Z	Z	X	X

(*a*) I (*b*) I and II

(*c*) III (*d*) IV

UNIT 2: PROTEIN CHEMISTRY

17. Consider a 51-residue long protein containing only 100 bonds about which rotation can occur. Assume that 3 orientations per bond are possible. Based on these assumptions, how many conformations will be possible for this protein?

(*a*) 3^{100} (*b*) 100^3

(*c*) 3^{51} (*d*) 51 × 100 × 3

18. A protein has one tryptophan and one, tyrosine in its sequence. Assume molar extinction coefficients at 280 nm of tryptophan and tyrosine as 3000 and 1500 $M^{-1}cm^{-1}$, respectively. What would be the molar concentration of that protein if its absorption at 280 nm is 0.90?

(*a*) 2 mM (*b*) 0.4 mM

(*c*) 0.2 mM (*d*) 0.02 mM

19. A and B Two cell surface receptors, A and B with a single binding site specifically bind with their respective ligands, X and Y. In the table below are the values for the association constant, k_a of the respective ligand-receptor interactions. k_a is also called the affinity constant.

Receptor	Ligand	K_a
A	X	1×10^8
B	Y	1×10^{11}

Based on these values, which one of the following statements is INCORRECT?

(*a*) K_d for B–Y binding is smaller than that for A binding.

(*b*) K_1 for A–X binding is lesser than that for B–Y binding.

(*c*) K_{-1} for B–Y binding is smaller than that for A–X binding.

(*d*) K_{-1}/k_1 for B–Y binding is higher than that for A–X binding (K_1 is the forward rate constant, K_{-1} is the reverse rate constant and K_d is the dissociation constant)

20. The following disulfide bond containing peptide was digested using trypsin. How many peptide fragments will be produced by the digestion?

(*a*) Three (*b*) Four

(*c*) Five (*d*) Six

21. An antibody binds to antigen with a K_d of 5×10^{-8} M. At what concentration of antigen will θ be 0.2?

(*a*) 1×10^{-8} M (*b*) 1×10^{-5} M

(*c*) 5×10^{-8} M (*d*) 5×10^{-5} M

22. A substrate binds 100 times as tightly to the R state of an allosteric enzyme as to its T state. Assume that the concerted (MWC) model applies to this enzyme. (a) By what factor does the binding of one substrate molecule per enzyme molecule alter the ratio of the concentrations of enzyme molecules in the R and T states? (b) Suppose that L, the ratio of [T] to [R] in the absence of substrate, is 10^7 and that the enzyme contains four binding sites for substrate. What is the ratio of enzyme molecules in the R state to that in the T state in the presence of saturating amounts of substrate, assuming that the concerted model is obeyed?

(*a*) 10, 100 (*b*) 100, 10

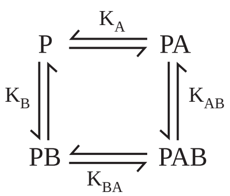
(*c*) 10, 1000 (*d*) 1000, 10

23. There are three hypothetical polypeptide namely P, Q & R and each consists of 100 amino acids. They have different peptide sequences with dissimilar secondary structures. If P exists in α helix, Q exists in π helix and R exists in 310 helix, what would be their respective axial length?
(*a*) 360A°, 160A°, 200A°
(*b*) 150A°, 180A°, 100A°
(*c*) 150A°, 80A°, 200A°
(*d*) 50A°, 100A°, 200A°

24. The proteins in a mammalian cell account for 18% of its net weight. If the density of a typical mammalian cell is about 1.1 g/ml and the volume of the cell is 4×10^{-9} ml, what is the concentration of protein in mg/ml?
(*a*) 100 mg/ml (*b*) 200 mg/ml
(*c*) 300 mg/ml (*d*) 400 mg/ml

25. You have purified a protein and trying to characterize its structure and function. You have analyzed that 50 residue segment of that protein folded into a two-stranded anti-parallel β structure with a 4 residue hairpin turn. What will be the longest dimension of that motif of your purified protein?
(*a*) 80.5 A° (*b*) 74 A°
(*c*) 68.5 A° (*d*) 93.5 A°

26. The concept of linkage is crucial for the understanding of many biochemical processes. Consider a protein molecule P that can bind A or B or both:



The dissociation constants for these equilibrium are defined as $K_A = [P][A]/[PA]$, $K_B = [P][B]/[PB]$, $K_{BA} = [PB][A]/[PAB]$, $K_{AB} = [PA][B]/[PAB]$. Suppose $K_A = 5 \times 10^{-4}$ M, $K_B = 10^{-3}$ M and $K_{BA} = 10^{-5}$ M. What will be the value of K_{AB}?
(*a*) 10^{-7} M (*b*) 10^{-5} M
(*c*) 2×10^{-7} M (*d*) 2×10^{-5} M

27. Suppose you are working as a hair bio-analyst in a hair therapy laboratory. Your job is to analyze hair growth and development. Suppose the rate of hair growth is 20 cm/year. How many helical turns you could expect in α-helix per min in a growing hair in order to judge proper hair growth?
(*a*) 35 (*b*) 50
(*c*) 70 (*d*) 90

28. You are working as a summer trainee in a protein biochemistry lab. You prepared a protein solution by weighing 20 mg dissolved in 2 mL water. You measured concentration of the protein by adding 0.25 mL of the protein solution to 0.75 mL water. The absorbance (A_{280}) of the diluted protein was found to be 0.355. The absorption coefficient of the protein is 0.45 (mg $mL^{-1})^{-1}$ cm^{-1}. Calculate the original concentration of the protein.
(*a*) 1.88 mg mL^{-1} (*b*) 2.32 mg mL^{-1}
(*c*) 3.12 mg mL^{-1} (*d*) 3.54 mg mL^{-1}

29. A protein sample elutes from an ion exchange column at a NaCl concentration of 1.2 M. The pooled protein has a volume of 50 mls (and a NaCl concentration of 1.2 M). We would like to proceed with the next step of purification, but first we must reduce the NaCl concentration to 5 mM. You will dialyze the sample versus water. If you wanted to perform this dialysis in a single step, how large a volume of dialysis buffer (i.e. water) would you need?
(*a*) 10 liters (*b*) 12 liters
(*c*) 15 liters (*d*) 20 liters

30. A protein sample with a volume of 350 ml contains NaCl at a concentration of 2.1 M. The sample is dialyzed versus 3.5 liters of 0.5 M NaCl. The resulting sample is then dialyzed versus 7.0 liters of distilled water. What is the final concentration of NaCl in the sample?
(*a*) 10.7 mM (*b*) 20.7 mM
(*c*) 30.7 mM (*d*) 40.7 mM

31. A hypothetical polypeptide hormone binds to its receptor with an association rate constant (k_a) of 3.0×10^4 M^{-1} sec^{-1} and a dissociation rate constant (k_d) of 6.9×10^{-6} sec^{-1}. What is the equilibrium dissociation constant?
(*a*) 4.7×10^9 M^{-1} (*b*) 2.3×10^{-10} M
(*c*) 2.3×10^{10} M^{-1} (*d*) 3.3×10^{-6} M

32. What would be the number of protein molecules present in 1.0 mg of protein having a molecular weight of 25 kDa?
(*a*) 2.4×10^{15} (*b*) 2.4×10^{16}
(*c*) 2.4×10^{17} (*d*) 2.4×10^{18}

33. The average density of a soluble protein is 1.33 g/cm^3. What is the specific volume of average soluble protein?
(*a*) 1 ml/g (*b*) 0.25 ml/g
(*c*) 0.7 ml/g (*d*) 0.75 ml/g

34. Hemoglobin contains 0.335% iron by weight. Calculate the minimum molecular weight of Hemoglobin.
(*a*) 20,200 g (*b*) 20,500 g
(*c*) 16,200 g (*d*) 16,672 g

35. The length of an α-helix composed of 36 amino acid residues is ________.
(*a*) 10 Å (*b*) 54 Å
(*c*) 27 Å (*d*) 360 Å

36. What is the chemical shift if a nuclear magnetic resonance transition is shifted from the reference in a 510 MHz NMR spectrometer by 624 Hz?
(*a*) 1.54 (*b*) 1.22
(*c*) 1.38 (*d*) 1.34

37. For performing an experiment in a laboratory, a research scholar fused a protein 'P' with Green Fluorescent Protein. The length of the protein 'P' is 1500 amino acids and the molecular mass of GFP is 27 kDa. Then approximately what would be the total molecular mass of the fusion protein in Daltons?
(*a*) 192000 Da (*b*) 170000 Da
(*c*) 107000 Da (*d*) 147000 Da

38. If a protein contains four cysteine residues, the number of different ways they can simultaneously form two intra-molecular disulphide bonds is
(*a*) 3 (*b*) 4 (*c*) 8 (*d*) 16

39. If the chemical composition of proteins in an organism is $CH_{1.5}O_{0.3}N_{0.3}S_{0.004}$, the mass percentage of carbon in the proteins is
Given data: π = Atomic weights (Da) of C = 12, H = 1, O = 16, N = 14 and S = 32.
(*a*) 20 (*b*) 25
(*c*) 45 (*d*) 55

40. The percentage SIMILARITIES and IDENTITIES, respectively, between the two peptide sequences given below will be ______% and _____%.
Peptide I: Ala-Ala-Arg-Arg-Gln-Trp-Leu-Thr-Phe-Thr-Lys-Ile-Met-Ser-Glu
Peptide II: Ala-Ala-Arg-Glu-Gln-Tyr-Ile-Ser-Phe-Thr-Lys-Ile-Met-Arg-Asp
(*a*) 80, 80 (*b*) 80, 60
(*c*) 60, 60 (*d*) 90, 60

41. In the structure of a polypeptide, one α-helix (3.6_{13} helix) contains 32 intra-chain hydrogen bonds. The number of turns in the helix will be ________ (*in integer*).
(*a*) 10 (*b*) 13
(*c*) 16 (*d*) 32

42. The bacteriorhodpsin has 248 amino acids and 7 transmembrane segments. Approximately, what portion of the amino acids are part of the transmembrane segments? Assume that the remaining amino acids are present in the hydrophilic loops linking the transmmebrane domain, how many amino acids are present in each of these loops?
(*a*) 22% of the protein; 28 amino acids
(*b*) 75% of the protein; 6 amino acids
(*c*) 45% of the protein; 12 amino acids
(*d*) 52% of the protein; 8 amino acids

43. Which peptide bond (s) marked as a, b, c, d and e will be broken when the following oligopeptide is treated with trypsin at pH 7.0?
Lys—(a)—Arg—(b)—Pro—(c)—Lys—(d)—Arg—(e)—Gly
(*a*) a, b, d, e (*b*) b, d, e
(*c*) d, e (*d*) d

UNIT 3: BEER LAMBERT LAW

44. A ribonuclase solution gave an absorbance of 1.0 at 278 nm in a UV spectrometer using a 1 cm quartz cuvette. Given that the molar extinction coefficient of the enzyme at 278 nm is 10^2 $M^{-1}cm^{-1}$, the concentration of the enzyme would be
(*a*) 1 mM (*b*) 20 mM
(*c*) 10 mM (*d*) 100 mM

45. A BSA stock solution is diluted 10 folds with phosphate buffer. The absorbance of the solution in a quartz cuvette of pathlength 1 mm at 281.5 nm is 0.330. If the extinction coefficient of the protein is 0.66 ml/mg.cm, the concentration of the stock protein solution would be
(*a*) 5 mg/ml (*b*) 20 mg/ml
(*c*) 33 mg/ml (*d*) 50 mg/ml

46. Concentration of a protein solution determined using its extinction coefficient resulted in a value of 1 mg/ml. Given that its molecular weight is 100 kDa, its concentration in molar units will be-
(*a*) 10 μM (*b*) 100 μM
(*c*) 1 mM (*d*) 10 mM

47. A solution of tryptophan has an absorbance at 280 nm of 0.54 in a 0.5 cm path length cuvette. Given the molar extinction coefficient for Trp is 5.4×10^3 mol^{-1} cm^{-1}, concentration of the solution.
(*a*) 2 mM (*b*) 0.5 mM
(*c*) 0.2 mM (*d*) 1 M

48. A solution containing 2 gram/litre of a light absorbing substance in a 1 cm cuvette transmits 75% of the incident light of a certain wavelength. Calculate the absorbance of the solution.

(*a*) 0.0625 (*b*) 0.625
(*c*) 6.25 (*d*) 0.00625

49. For an experiment, a solution contains two substances M and N, has an absorbance in a 1 cm cuvette of 0.36 at 350 nm and 0.225 at 400 nm. The molar absorption coefficients (ε) ($M^{-1} \times cm^{-1}$) of the two substance at the two wavelengths are shown in the table below. The concentration of N is 3×10^{-5} M.

Compound	ε at 350 nm	ε at 400 nm
M	15, 000	300
N	7, 000	6500

What is the concentration of M in the solution?

(*a*) 3×10^{-5} M (*b*) 3×10^{-1} M
(*c*) 2×10^{-2} M (*d*) 1×10^{-5} M

50. An aqueous solution contains two compounds X and Y. This solution gave absorbance values of 1.0 and 0.4 at 220 and 280 nm, respectively, in a 1 cm path length cell. Molar absorption coefficients (ε) of the compounds X and Y are as shown in the table below:

Compound	ε 220 (M^{-1} cm^{-1})	ε 280 (M^{-1} cm^{-1})
Compound X	1000	200
Compound Y	800	400

The concentration of Y in the solution is _______ mM.

(*a*) 0.083 (*b*) 0.83
(*c*) 8.3 (*d*) 83

51. The predicted molar extinction coefficient at 280 nm for the peptide

GEEFHISFLLIMFGAWSTHMYRTYWFIHEMIS TRY is ________ M^{-1} cm^{-1}.

[Molar extinction coefficients for phenylalanine, tryptophan and tyrosine at 280 nm are 200, 5600 and 1400 M^{-1} cm^{-1} respectively]

(*a*) 16.2 (*b*) 162
(*c*) 1620 (*d*) 16200

52. In an experiment, a test tube contains NAD^+ and NADH solution with optical density of 0.311 at 340 nm and 1.2 at 260 nm in a 1 cm cuvette. NAD^+ and NADH both absorb at 260 nm, but only NADH absorbs at 340 nm.

Compound	Extinction coefficients (ε) ($M^{-1} \times cm^{-1}$) at 260 nm	Extinction coefficients (ε) ($M^{-1} \times cm^{-1}$) at 340 nm
NAD^+	18, 000	~0
NADH	15, 000	6220

What is the concentration of NAD^+ in the solution?

(*a*) 3×10^{-3} M (*b*) 2×10^{-5} M
(*c*) 2.5×10^{-5} M (*d*) 5×10^{-2} M

53. In a test tube 3.0 g of L-leucine was dissolved in 100 ml of 6 N HCl. It has an observed rotation of +1.81° in a 25 cm polarimeter tube. Select the specific rotation of L-leucine in 6 N HCl.

(*a*) 42.8° (*b*) 70.5°
(*c*) 24.13° (*d*) 12.14°

54. Aqueous solution of D-galactose has an $[\alpha]D^{25}$ of +80.2° after standing for some hours. +150.7° and +52.8° are specific rotations of pure α-D-galactose and β-D-galactose. Chose the proportions of α-D-galactose and β-D-galactose in the equilibrium mixture.

(*a*) 72% of α-anomer and 28% of β-anomer
(*b*) 38% of α-anomer and 62% of β-anomer
(*c*) 62% of α-anomer and 38% of β-anomer
(*d*) 28% of α-anomer and 72% of β-anomer

55. A UV-visible spectrophotometer has a minimum detectable absorbance of 0.02. The minimum concentration of a protein sample that can be measured reliably in this instrument with a cuvette of 1 cm path length is ________ μM. The molar extinction coefficient of the protein is 10,000 L mol^{-1} cm^{-1} (rounded off to the nearest integer). (R = 1.987 cal mol^{-1} K^{-1}, T = 37°C)

(*a*) 1 (*b*) 2
(*c*) 8 (*d*) 12

56. The absorbance of a solution of tryptophan measured at 280 nm in a cuvette of 2.0 cm path length is 0.56 at pH 7. The molar extinction coefficient (ε) for tryptophan at 280 nm is 5600 M^{-1} cm^{-1} at pH 7. The concentration of tryptophan (in μM) in the solution is

(*a*) 30 (*b*) 40
(*c*) 50 (*d*) 90

57. The concentration (in micromolar) of NADH in a solution with A_{340} = 0.50 is ______.
Given data: Path length = 1 cm; Molar extinction coefficient of NADH ∈ = 6220 M^{-1} cm^{-1}.

(*a*) 20.5 (*b*) 54.2
(*c*) 78.4 (*d*) 80.4

58. Guanosine has a maximum absorbance of 275 nm. ε@275 = 8400$M^{-1}cm^{-1}$ and the path length is 1 cm. Using a spectrophotometer, you find that A@275 = 0.70. What is the concentration of guanosine?

(*a*) 8.33×10^{-5} mol/L (*b*) 8.33×10^{-4} mol/L
(*c*) 833×10^{-5} mol/L (*d*) 83.3×10^{-5} mol/L

59. The wavelength of the sodium D line is 589 nm. What are the frequency for this line?

(*a*) 5.09×10^{14} S^{-1} (*b*) 5.09×10^{14} S^{-1}
(*c*) 5.09×10^{14} S^{-1} (*d*) 5.09×10^{14} S^{-1}

60. A protein sample with a volume of 350 ml contains NaCl at a concentration of 2.1 M. The sample is dialyzed versus 3.5 liters of 0.5 M NaCl. The resulting sample is then dialyzed versus 7.0 liters of distilled water. What is the final concentration of NaCl in the sample?

(*a*) 10.7 mM (*b*) 20.7 mM
(*c*) 30.7 mM (*d*) 40.7 mM

61. The ultraviolet spectrum of benzonitrile shows a secondary absorption band at 271 nm. If a solution of benzonitrile in water, with a concentration of 1×10^{-4} molar solution is examined at 271 nm, what will be the absorbance reading (ε = 1000) and what will be the intensity ratio, I_0/I, respectively?

(*a*) 0.1, 1.26 (*b*) 0.2, 2.26
(*c*) 0.3, 3.26 (*d*) 0.4, 4.26

UNIT 4: PROTEIN PURIFICATION

62. Assuming that the fold-purification and yields are similar if the steps are done sequentially as compared to being done separately, what would be the expected specific activity following combined gel filtration and isoelectric focusing?

(*a*) 1800 units/mg (*b*) 2700 units/mg
(*c*) 3900 units/mg (*d*) 4200 units/mg

63. One microgram of a pure enzyme (MW: 92,000) catalyzed a reaction at a rate of 0.50 μmoles/min under optimum conditions. The specific activity of the enzyme [(μmoles/min)/mg protein] is-

(*a*) 0.5 (*b*) 5.0
(*c*) 500 (*d*) 5000

64. The mean extracellular cellulase activity of 7 Bacillus strains isolated from soil was determined to be 12 IU/mL. A new hyper-producing Bacillus isolate was found to have an extracellular activity of 36 IU/mL. If equal volumes of the supernatants of all 8 strains are mixed together, the cellulase activity of the solution will be

(*a*) 13.5 (*b*) 15
(*c*) 16.5 (*d*) 17.5

65. The activity of Enzyme X (total volume 5.3 ml) is 2.34 micromoles of product formed per min. The total protein content of this solution is 0.8 mg. What is the specific activity?

(*a*) 2.93 (*b*) 1.87
(*c*) 18.2 (*d*) 15.5

66. Purification data for an enzyme is given below:-

Steps	Purification step	Volume (ml)	Total protein (mg)	Total activity (micromoles per min)
I	Cell-free extract	20	100	150
II	Ni-NTA chromatography	4	10	120

What is the fold-purification?

(*a*) 8 (*b*) 13.5
(*c*) 10.5 (*d*) 18

67. The cell-free extract prepared from *E. coli* cells over-expressing enzyme β-glucosidase showed the activity of 1.5 units per ml (protein concentration 2 mg per ml). The Ni-NTA purified preparation showed the activity of 75 units per ml (protein concentration 100 μg per ml). Calculate the fold purification of the enzyme achieved?

(*a*) 0.001 (*b*) 0.02
(*c*) 50 (*d*) 1000

68. Enzyme X showed its activity on substrate A (375 units per ml), substrate B (185 units per ml) and substrate C (75 units per ml). With respect to substrate A, the percent activities on substrate B and C are ______, respectively.

(*a*) 0.49 & 0.2 (*b*) 2.02 & 5
(*c*) 49 & 20 (*d*) 202 & 500

69. A paper chromatogram sets up by a researcher and on the origin he places a spot of green food dye. It was noted that after 6 minutes the solvent has moved 12 cm and a blue spot has advanced 9 cm. After 14 minutes the solvent has advanced a further 8 cm. How many cm from the origin is the blue spot likely to be?

(*a*) 15 cm (*b*) 12 cm
(*c*) 8 cm (*d*) 4 cm

Answer Keys

Chapter-01 : ANALYTICAL CHEMISTRY

1. (*c*)	**2.** (*a*)	**3.** (*b*)	**4.** (*d*)	**5.** (*b*)	**6.** (*c*)	**7.** (*b*)	**8.** (*a*)	**9.** (*b*)	**10.** (*a*)
11. (*d*)	**12.** (*c*)	**13.** (*d*)	**14.** (*a*)	**15.** (*d*)	**16.** (*a*)	**17.** (*d*)	**18.** (*a*)	**19.** (*b*)	**20.** (*a*)
21. (*d*)	**22.** (*d*)	**23.** (*d*)	**24.** (*a*)	**25.** (*c*)	**26.** (*b*)	**27.** (*c*)	**28.** (*c*)	**29.** (*a*)	**30.** (*c*)
31. (*d*)	**32.** (*a*)	**33.** (*d*)	**34.** (*c*)	**35.** (*b*)	**36.** (*c*)	**37.** (*d*)	**38.** (*a*)	**39.** (*d*)	**40.** (*d*)
41. (*a*)	**42.** (*b*)	**43.** (*c*)	**44.** (*a*)	**45.** (*d*)	**46.** (*b*)	**47.** (*c*)	**48.** (*c*)	**49.** (*c*)	**50.** (*d*)
51. (*a*)	**52.** (*b*)	**53.** (*c*)	**54.** (*d*)	**55.** (*a*)	**56.** (*b*)	**57.** (*c*)	**58.** (*c*)	**59.** (*d*)	**60.** (*c*)
61. (*c*)	**62.** (*b*)	**63.** (*d*)	**64.** (*d*)	**65.** (*a*)	**66.** (*a*)	**67.** (*c*)	**68.** (*d*)	**69.** (*d*)	**70.** (*d*)
71. (*d*)	**72.** (*b*)	**73.** (*d*)	**74.** (*d*)	**75.** (*d*)	**76.** (*d*)	**77.** (*b*)	**78.** (*c*)	**79.** (*c*)	**80.** (*d*)
81. (*c*)	**82.** (*d*)	**83.** (*b*)	**84.** (*a*)	**85.** (*c*)	**86.** (*d*)				

Chapter-02 : BIOCHEMISTRY

1. (*b*)	**2.** (*a*)	**3.** (*a*)	**4.** (*c*)	**5.** (*a*)	**6.** (*a*)	**7.** (*d*)	**8.** (*b*)	**9.** (*b*)	**10.** (*d*)
11. (*c*)	**12.** (*b*)	**13.** (*b*)	**14.** (*a*)	**15.** (*a*)	**16.** (*a*)	**17.** (*a*)	**18.** (*c*)	**19.** (*d*)	**20.** (*a*)
21. (*a*)	**22.** (*b*)	**23.** (*c*)	**24.** (*b*)	**25.** (*a*)	**26.** (*d*)	**27.** (*c*)	**28.** (*c*)	**29.** (*b*)	**30.** (*c*)
31. (*b*)	**32.** (*b*)	**33.** (*c*)	**34.** (*d*)	**35.** (*b*)	**36.** (*b*)	**37.** (*a*)	**38.** (*a*)	**39.** (*d*)	**40.** (*b*)
41. (*a*)	**42.** (*b*)	**43.** (*d*)	**44.** (*c*)	**45.** (*d*)	**46.** (*a*)	**47.** (*c*)	**48.** (*a*)	**49.** (*d*)	**50.** (*b*)
51. (*d*)	**52.** (*c*)	**53.** (*c*)	**54.** (*d*)	**55.** (*b*)	**56.** (*c*)	**57.** (*d*)	**58.** (*a*)	**59.** (*c*)	**60.** (*c*)
61. (*a*)	**62.** (*c*)	**63.** (*c*)	**64.** (*b*)	**65.** (*a*)	**66.** (*a*)	**67.** (*d*)	**68.** (*c*)	**69.** (*a*)	**70.** (*b*)
71. (*c*)	**72.** (*d*)	**73.** (*d*)	**74.** (*a*)	**75.** (*b*)	**76.** (*c*)	**77.** (*d*)	**78.** (*d*)	**79.** (*c*)	**80.** (*a*)
81. (*b*)	**82.** (*a*)	**83.** (*a*)	**84.** (*d*)	**85.** (*a*)	**86.** (*c*)	**87.** (*a*)	**88.** (*b*)	**89.** (*b*)	**90.** (*c*)
91. (*c*)	**92.** (*d*)	**93.** (*c*)	**94.** (*d*)	**95.** (*c*)	**96.** (*a*)	**97.** (*c*)	**98.** (*c*)	**99.** (*b*)	**100.** (*a*)
101. (*c*)	**102.** (*d*)	**103.** (*a*)	**104.** (*d*)	**105.** (*b*)	**106.** (*c*)	**107.** (*c*)	**108.** (*b*)	**109.** (*a*)	**110.** (*c*)
111. (*c*)	**112.** (*d*)	**113.** (*c*)	**114.** (*d*)	**115.** (*c*)	**116.** (*b*)	**117.** (*a*)	**118.** (*c*)	**119.** (*d*)	**120.** (*d*)
121. (*b*)	**122.** (*c*)	**123.** (*a*)	**124.** (*a*)	**125.** (*b*)	**126.** (*c*)	**127.** (*a*)	**128.** (*b*)	**129.** (*c*)	**130.** (*c*)
131. (*d*)	**132.** (*a*)	**133.** (*d*)	**134.** (*a*)	**135.** (*c*)	**136.** (*d*)	**137.** (*d*)	**138.** (*b*)	**139.** (*a*)	**140.** (*d*)
141. (*b*)	**142.** (*b*)	**143.** (*c*)	**144.** (*b*)	**145.** (*b*)	**146.** (*b*)	**147.** (*d*)	**148.** (*c*)	**149.** (*b*)	**150.** (*b*)
151. (*c*)	**152.** (*a*)	**153.** (*b*)	**154.** (*b*)	**155.** (*c*)	**156.** (*c*)	**157.** (*b*)	**158.** (*c*)	**159.** (*c*)	**160.** (*d*)
161. (*a*)	**162.** (*b*)	**163.** (*d*)	**164.** (*a*)	**165.** (*a*)	**166.** (*a*)	**167.** (*c*)	**168.** (*d*)	**169.** (*a*)	**170.** (*a*)
171. (*a*)	**172.** (*d*)	**173.** (*b*)	**174.** (*a*)	**175.** (*a*)	**176.** (*a*)	**177.** (*a*)	**178.** (*c*)	**179.** (*a*)	**180.** (*c*)
181. (*d*)	**182.** (*a*)	**183.** (*a*)	**184.** (*a*)	**185.** (*c*)	**186.** (*d*)	**187.** (*a*)	**188.** (*b*)	**189.** (*b*)	**190.** (*a*)
191. (*b*)	**192.** (*a*)	**193.** (*d*)	**194.** (*b*)	**195.** (*d*)	**196.** (*c*)	**197.** (*a*)	**198.** (*c*)	**199.** (*c*)	**200.** (*d*)
201. (*d*)	**202.** (*a*)	**203.** (*d*)	**204.** (*d*)	**205.** (*d*)	**206.** (*d*)	**207.** (*d*)	**208.** (*c*)	**209.** (*c*)	**210.** (*c*)
211. (*d*)	**212.** (*c*)	**213.** (*c*)	**214.** (*c*)	**215.** (*b*)	**216.** (*d*)	**217.** (*d*)	**218.** (*d*)	**219.** (*b*)	**220.** (*c*)
221. (*a*)	**222.** (*b*)	**223.** (*c*)							

Chapter-03 : CELL BIOLOGY

1. (*d*)	**2.** (*d*)	**3.** (*c*)	**4.** (*d*)	**5.** (*b*)	**6.** (*b*)	**7.** (*d*)	**8.** (*b*)	**9.** (*d*)	**10.** (*a*)
11. (*d*)	**12.** (*a*)	**13.** (*b*)	**14.** (*d*)	**15.** (*d*)	**16.** (*b*)	**17.** (*b*)	**18.** (*a*)	**19.** (*c*)	**20.** (*a*)
21. (*a*)	**22.** (*b*)	**23.** (*c*)	**24.** (*c*)	**25.** (*d*)	**26.** (*a*)	**27.** (*c*)	**28.** (*a*)	**29.** (*c*)	**30.** (*d*)
31. (*b*)	**32.** (*c*)	**33.** (*d*)	**34.** (*c*)	**35.** (*c*)	**36.** (*d*)	**37.** (*b*)	**38.** (*b*)	**39.** (*b*)	**40.** (*c*)
41. (*a*)	**42.** (*b*)	**43.** (*c*)	**44.** (*a*)	**45.** (*c*)	**46.** (*a*)	**47.** (*b*)	**48.** (*a*)	**49.** (*d*)	**50.** (*d*)
51. (*c*)	**52.** (*b*)	**53.** (*b*)	**54.** (*d*)	**55.** (*a*)	**56.** (*b*)				

Chapter-04 : MICROBIOLOGY

1. (*c*)	**2.** (*d*)	**3.** (*c*)	**4.** (*d*)	**5.** (*c*)	**6.** (*d*)	**7.** (*b*)	**8.** (*c*)	**9.** (*b*)	**10.** (*c*)
11. (*c*)	**12.** (*c*)	**13.** (*d*)	**14.** (*c*)	**15.** (*a*)	**16.** (*c*)	**17.** (*d*)	**18.** (*c*)	**19.** (*c*)	**20.** (*c*)
21. (*b*)	**22.** (*b*)	**23.** (*c*)	**24.** (*a*)	**25.** (*b*)	**26.** (*a*)	**27.** (*c*)	**28.** (*a*)	**29.** (*a*)	**30.** (*b*)
31. (*a*)	**32.** (*a*)	**33.** (*a*)	**34.** (*d*)	**35.** (*b*)	**36.** (*a*)	**37.** (*a*)	**38.** (*d*)	**39.** (*b*)	**40.** (*b*)
41. (*a*)	**42.** (*b*)	**43.** (*d*)	**44.** (*a*)	**45.** (*a*)	**46.** (*d*)	**47.** (*d*)	**48.** (*d*)	**49.** (*a*)	**50.** (*d*)
51. (*d*)	**52.** (*c*)	**53.** (*c*)	**54.** (*d*)	**55.** (*a*)	**56.** (*d*)	**57.** (*b*)	**58.** (*d*)	**59.** (*c*)	**60.** (*d*)
61. (*c*)	**62.** (*c*)	**63.** (*d*)	**64.** (*b*)	**65.** (*b*)					

Chapter-05 : GENETICS

1. (*a*)	**2.** (*b*)	**3.** (*b*)	**4.** (*d*)	**5.** (*b*)	**6.** (*a*)	**7.** (*a*)	**8.** (*c*)	**9.** (*c*)	**10.** (*a*)
11. (*d*)	**12.** (*b*)	**13.** (*b*)	**14.** (*b*)	**15.** (*a*)	**16.** (*a*)	**17.** (*a*)	**18.** (*a*)	**19.** (*c*)	**20.** (*b*)
21. (*b*)	**22.** (*d*)	**23.** (*b*)	**24.** (*a*)	**25.** (*c*)	**26.** (*b*)	**27.** (*c*)	**28.** (*c*)	**29.** (*b*)	**30.** (*a*)
31. (*a*)	**32.** (*c*)	**33.** (*c*)	**34.** (*b*)	**35.** (*c*)	**36.** (*c*)	**37.** (*b*)	**38.** (*c*)	**39.** (*b*)	**40.** (*b*)
41. (*a*)	**42.** (*d*)	**43.** (*c*)	**44.** (*d*)	**45.** (*a*)	**46.** (*d*)	**47.** (*a*)	**48.** (*a*)	**49.** (*b*)	**50.** (*a*)
51. (*d*)	**52.** (*a*)	**53.** (*d*)	**54.** (*a*)	**55.** (*b*)	**56.** (*a*)	**57.** (*a*)	**58.** (*b*)	**59.** (*c*)	**60.** (*b*)
61. (*d*)	**62.** (*b*)	**63.** (*c*)	**64.** (*b*)	**65.** (*a*)	**66.** (*b*)	**67.** (*c*)	**68.** (*b*)	**69.** (*b*)	**70.** (*c*)
71. (*c*)	**72.** (*c*)	**73.** (*b*)	**74.** (*d*)	**75.** (*b*)	**76.** (*c*)	**77.** (*c*)	**78.** (*c*)	**79.** (*a*)	**80.** (*a*)
81. (*c*)	**82.** (*c*)	**83.** (*c*)	**84.** (*b*)	**85.** (*b*)	**86.** (*c*)	**87.** (*b*)	**88.** (*d*)	**89.** (*b*)	**90.** (*b*)
91. (*a*)	**92.** (*a*)	**93.** (*c*)	**94.** (*c*)	**95.** (*a*)	**96.** (*b*)	**97.** (*c*)	**98.** (*c*)	**99.** (*a*)	**100.** (*c*)
101. (*b*)	**102.** (*c*)								

Chapter-06 : MOLECULAR BIOLOGY

1. (*a*)	**2.** (*c*)	**3.** (*b*)	**4.** (*d*)	**5.** (*c*)	**6.** (*c*)	**7.** (*b*)	**8.** (*a*)	**9.** (*a*)	**10.** (*d*)
11. (*a*)	**12.** (*c*)	**13.** (*b*)	**14.** (*c*)	**15.** (*d*)	**16.** (*d*)	**17.** (*d*)	**18.** (*c*)	**19.** (*b*)	**20.** (*d*)
21. (*c*)	**22.** (*c*)	**23.** (*d*)	**24.** (*c*)	**25.** (*a*)	**26.** (*b*)	**27.** (*d*)	**28.** (*b*)	**29.** (*b*)	**30.** (*a*)
31. (*a*)	**32.** (*a*)	**33.** (*c*)	**34.** (*c*)	**35.** (*b*)	**36.** (*c*)	**37.** (*d*)	**38.** (*d*)	**39.** (*a*)	**40.** (*c*)
41. (*d*)	**42.** (*c*)	**43.** (*d*)	**44.** (*d*)	**45.** (*c*)	**46.** (*d*)	**47.** (*d*)	**48.** (*b*)	**49.** (*c*)	**50.** (*b*)
51. (*b*)	**52.** (*b*)	**53.** (*d*)	**54.** (*d*)	**55.** (*a*)	**56.** (*c*)	**57.** (*b*)	**58.** (*b*)	**59.** (*c*)	**60.** (*c*)
61. (*c*)	**62.** (*c*)	**63.** (*d*)	**64.** (*c*)						

Explanations

Chapter-01 : ANALYTICAL CHEMISTRY

UNIT 1: pH AND BUFFER

1. (*c*) (1) This is the chemical reaction of interest:

$HNO_2 + H_2O \rightleftharpoons H_3O^+ + NO_2^-$

(2) The HNO_2 is diluted by the addition of $NaNO_2$ solution.

$M_1V_1 = M_2V_2$

(1.00 mol/L) (20.0 cm^3) = (x) (60.0 cm^3) = 0.333 M HNO_2 (the initial concentration of the HNO_2, before any reaction takes place)

(3) The NO_2^- concentration is 2/3 of its original concentration (going from 40.0 cm3 to 60.0 cm^3).

2/3 × 0.5 = 0.333 M NO_2^- (the initial concentration of the NO_2^-, before any reaction takes place)

(4) HNO_2 ionizing will result in more nitrite ion and less nitrous acid when compared to the initial concentrations. The new concentrations will be these:

$[HNO_2] = 0.333 - x$

$[NO_2^-] = 0.333 + x$

$[H3O^+] = x$

(5) However, we make the assumption that x is small compared to 0.333 and we drop the 'subtract x' and the 'add x' from our values. We are now ready to place values into the K_a expression:

$$K_a = \frac{[H_3O^+][NO_2]}{[NO_2]}$$

$$4.57 \times 10^{-4} = \frac{(x)(0.333)}{0.333}$$

(6) Since the HNO_2 and NO_2^- concentrations are the same, they will cancel out leaving the hydrogen ion concentration equal to the K_a:

$x = 4.57 \times 10^{-4}$ M ← this is the $[H_3O^+]$

(7) Calculate pH:

$pH = -\log [H^+]$

$pH = -\log 4.57 \times 10^{-4}$

pH = 3.34

Note that the pH of the solution is equal to the pK_a.

2. (*a*) Moles of NaOH = (0.100 mol/L) (0.0150 L) = 0.001500 mol

Moles of benzoic acid = (0.100 mol/L) (0.0300 L) = 0.00300 mol

NaOH and benzoic acid react in a 1 : 1 molar ratio. After reaction, we have:

moles of sodium benzoate = 0.00150 mol
moles of benzoic acid = 0.00150 mol

$pH = pK_a + \log$ [base/acid]

pH = 4.190 + log [0.00150/0.00150]

pH = 4.190

3. (*b*) Moles of NaOH = (0.500 mol/L) (0.00500 L) = 0.00250 mol

Moles of benzoic acid = (0.500 mol/L) (0.0200 L) = 0.00750 mol

NaOH and benzoic acid react in a 1 : 1 molar ratio. After reaction, we have:

moles of sodium benzoate = 0.00250 mol

moles of benzoic acid = 0.00750 mol

$pH = pK_a + \log$ [base / acid]

pH = 4.190 + log [0.00250 / 0.00750]

pH = 4.190 + (−0.477)

pH = 3.713

4. (*d*) (1) Use the Henderson-Hasselbalch Equation to solve this problem:

$pH = pK_a + \log$ [base / acid]

(2) I already know the pH, so:

$8.58 = pK_a + \log$ [base / acid]

(3) I need a pK_a, not a K_b or a pK_b. What I need is the pK_a of the ammonium ion. I get it from Kw and the K_b of ammonia:

$K_w = K_aK_b$

$1.00 \times 10^{-14} = (K_a)(1.77 \times 10^{-5})$

$K_a = 5.6497 \times 10^{-10}$

$pK_a = -\log 5.6497 \times 10^{-10} = 9.24797$ (I'll carry some extra digits.)

(4) Add that value in:

$8.58 = 9.24797 + \log$ [base / acid]

(5) Next are the moles of NH_3:

(0.400 mol/L) (1.50 L) = 0.600 mol

(6) Add it in:

$8.58 = 9.24797 + \log [0.6 / x]$

(7) The acid (which is the NH_4Cl, specifically the NH_4^+ part) is our unknown.

$8.58 = 9.24797 + \log [0.6 / x]$

$\log [0.6 / x] = -0.66797$

$0.6 / x = 0.2147979$

x = 2.7933234 mol

2.7933234 mol times 53.4916 g/mol = 149.42 g

(8) We can check this by going back to the H–H Eq (and I will use molarities):

pH = 9.24797 + log [base / acid]

pH = 9.24797 + log [0.400 / 1.8622156]

pH = 9.24797 + log 0.2147979

pH = 9.24797 + (−0.66797)

pH = 8.58

(9) The molarity of the NH_4Cl (used in step 8) came from this calculation:

2.7933234 mol / 1.50 L = 1.8622156 M

5. (*b*) pH = pK_a + log [base / acid]

8.90 = 9.248 + log [0.800 / x]

log [0.800 / x] = −0.348

[0.800 / x] = 0.4487454

x = 1.782748 M (this is the required molarity of the NH_4Cl

(1.782748 mol/L) (2.40 L) = mass / 53.4916 g/mol

mass = 228.8689 gm = 229 gm

6. (*c*) (1) The hydrogen ion from the HCl will protonate the acetate ion according to this reaction:

$H^+ + CH_3COO^- \rightarrow CH_3COOH$

The key point is that the reaction has a 1 : 1 molar ratio between the two reactants.

(2) The HCl is the limiting reagent. Some CH_3COOH will be made and some CH_3COO^- will be left over.

$CH_3COOH \rightarrow$ 0.030 mol is made (as a result of H+ + CH_3COO^-)

$CH_3COO^- \rightarrow$ 0.050 − 0.030 = 0.020 mol remains

(3) The Henderson-Hasselbalch Equation is used to determine the pH:

pH = pK_a + log [base / acid]

pH = 4.752 + log [0.020 / 0.030]

pH = 4.752 + (−0.176) = 4.58

7. (*b*) N.B. The presence of the sodium ion will be ignored since it is a spectator ion.

(1) The nitric acid is a strong acid and it will protonate the weaker acid, symbolized by $HCit_2^-$. This is the reaction:

$HCit_2^- + H^{+-} \rightarrow H_2Cit^-$ ← this reaction goes to completion, not an equilibrium

(2) If you flip the above reaction, you have the equation for the K_{a2} of citric acid:

$H_2Cit^- \rightleftharpoons HCit_2^- + H^+$ ← this reaction is an equilibrium

(3) We need to know how much $HCit_2^-$ reacted and how much H_2Cit^- was made:

moles $HNO_3 \rightarrow$ (0.027 mol/L) (0.133 L) = 0.003591 mol

moles $HCit_2^- \rightarrow$ (0.057 mol/L) (0.172 L) = 0.009804

How much H_2Cit^- was made? Answer: 0.003591 mol ← all the H^{+-} from the nitric acid was used up

How much $HCit_2^-$ remains? Answer: 0.009804 − 0.003591 = 0.006213 mol

The K_{a2} for citric acid is 1.73×10^{-5}. I found it

(4) We now use the Henderson-Hasselbalch equation since we have a buffer:

pH = pK_a + log [base / acid]

pH = pK_a + log ($HCit_2^-$ / H_2Cit^-)

Note: the $HCit_2^-$ is the base since it lacks the proton. The H_2Cit^- is the acid since it has the proton that gets donated to a water molecule to make H_3O^+ (signified in the equation in step 2 by H^+).

pH = 4.762 + log (0.006213 / 0.003591)

pH = 4.762 + 0.238

pH = 5.00

8. (*a*) (1) Determine pK_a:

4.30 = pK_a + log (0.33/0.26)

4.30 = pK_a + 0.104

pK_a = 4.196

You can also look up pK_a (or K_a) online. I decided to calculate it.

(2) Determine moles after addition of HCl:

0.33 − 0.058 = 0.272 mole sodium benzoate

0.26 + 0.058 = 0.318 mole benzoic acid

(3) Determine new pH:

pH = 4.196 + log (0.272 / 0.318)

pH = 4.196 + (−0.068)

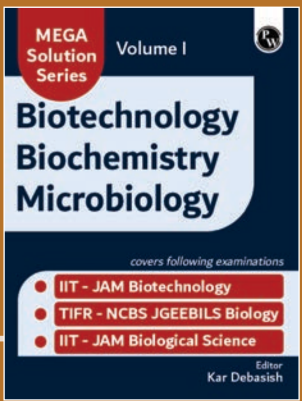
pH = 4.13

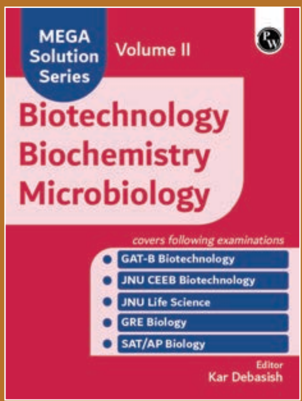
(4) Notice that the final volume of 1.60 L is not used. This is because the ratio of moles is the same as the ratio of molarities. Here is the Henderson-Hasselbalch

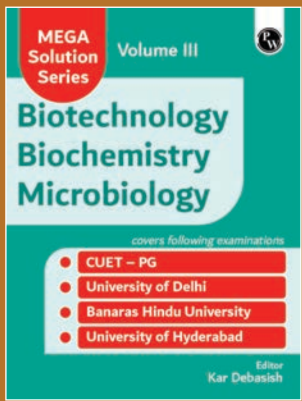
Features

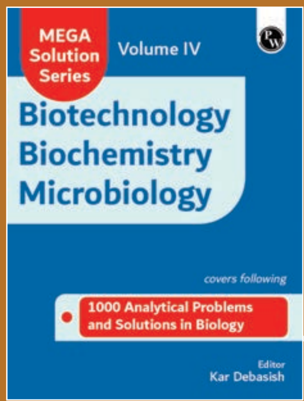
- Numerical problems and solutions in Analytical Chemistry
- Numerical problems and solutions in Biochemistry
- Numerical problems and solutions in Molecular Biology
- Numerical problems and solutions in Cell Biology
- Numerical problems and solutions in Evolution
- Numerical problems and solutions in Genetics
- Numerical problems and solutions in Ecology
- Numerical problems and solutions in Microbiology
- Numerical problems and solutions in Recombinant DNA Technology
- Numerical problems and solutions in Biochemical Engineering

Other Books in this Series









₹ 399/-

PHYSICS WALLAH PUBLICATION

To Buy PW Books
SCAN ME!

To share Feedback
SCAN ME!

ISBN 978-93-6034-369-9