

Problems (Calculations)
Medical Chemistry
2019/20, fall semester

1. How many grams of pure, solid NaOH are necessary to prepare 700 ml 16 w/w% solution if the density of the solution is 1.17 g/ml?
2. How many grams of NaOH are dissolved in 1 liter 30 w/w% solution? The density of the solution is 1.39 g/ml.
3. How many grams of NaCl should be dissolved in 500 g water to prepare a 20 w/w% NaCl solution?
4. 200 g NaCl have been dissolved in 1 kg water. Calculate the concentration of the solution both in w/w% and w/v% if its density is 1.15 g/ml.
5. What is the molarity and the molality of a solution prepared by dissolving 15 g NaOH in 400 g water (the density of the solution is 1.0 g/ml)? The molar mass of NaOH is 40 g/mol.
6. What is the molality of the solution prepared by dissolving 2 g NaCl in 100 ml water? The molar mass of NaCl is 58.5 g/mol.
7. What is the molarity of a 28 w/w% KOH solution ($d = 1.27$ g/ml)? The molar mass of KOH is 56 g/mol.
8. A 2 molal glycine solution was prepared by dissolving 15 g glycine in 100 ml water. What is the molar mass of glycine?
9. Calculate the normality of a 30 w/w% KOH (molar mass: 56 g/mol) solution if its density is 1.27 g/ml.
10. What is the mole fraction of HCl in its 36 w/w% aqueous solution? The molar mass of HCl is 36.5 g/mol and that of water is 18 g/mol.
11. How many grams of sulfuric acid (molar mass: 98 g/mol) are there in 5 liter 0.2 N H_2SO_4 solution?
12. Calculate the $[\text{H}^+]$ concentration of a solution prepared by mixing 40 ml 0.1 N sulfuric acid and 40 ml 0.2 M NaOH. Is this mixture acidic or basic?
13. 16.6 ml 0.01 N silver nitrate solution were consumed upon titration of 10 ml NaCl solution. What is the concentration of NaCl in w/v%? The molar mass of NaCl is 58.5 g/mol
14. Provide the concentration of a sulfuric acid solution in w/v% if 10 ml were neutralized by 17.5 ml, 0.1 N NaOH. The molar mass of sulfuric acid is 98 g/mol.

15. 10 ml oxalic acid solution [molar mass: 90 g/mol] react with 16.6 ml of 0.1 N KMnO_4 . What is its concentration in w/v%?
16. 10 ml of an unknown CuSO_4 solution react with 8.5 ml 0.02 N EDTA. Calculate the molar concentration of CuSO_4 .
17. Calculate the freezing point depression of a 1 w/v % aqueous solution of urea (molar mass: 60 g/mol) and NaCl (molar mass: 58.5 g/mol).
18. Calculate the freezing point depression of an aqueous solution prepared by mixing 50 ml 0.2 M KCl and 50 ml 0.04 M Na_2SO_4 .
19. Calculate the freezing point depression of a solution prepared by mixing 10 ml 0.1 N HCl and 10 ml 0.1 N NaOH.
20. Compare the osmotic pressure of a 0.1 w/v% NaCl (molar mass: 58.5 g/mol) and a 0.1 w/v% glucose (molar mass: 180 g/mol) solutions at 0 °C.
21. Calculate the osmotic concentration and osmotic pressure of a solution prepared by mixing 100 ml 0.2 M K_2SO_4 and 100 ml 0.1 M NaCl at 0 °C.
22. Calculate the osmolarity of a solution obtained by mixing 10 ml 0.1 M sulfuric acid and 20 ml 0.1 N sodium hydroxide.
23. The $[\text{H}^+]$ concentration of a 0.01 M monoprotic organic acid solution is 10^{-4} . Calculate the degree of dissociation and the dissociation constant of this acid.
24. The degree of dissociation in a 0.1 M acetic acid solution is 0.013. At which concentration is $\alpha = 0.90$?
25. What is the degree of dissociation in a 0.02 N acid solution if $K_a = 3 \times 10^{-5}$?
26. What is the pH of a 0.01 μM HCl solution?
27. What is the pH of a mixture of 50 ml 0.45 M sulfuric acid and 50 ml 1 M NaOH?
28. 20 ml 10 w/w% hydrochloric acid ($d = 1.05$ g/ml; molar mass = 36.5 g/mol) are diluted to 5 liter. Calculate the pH of the diluted solution.
29. What is the pH of a 0.01 M NaOH solution?
30. The degree of dissociation of a weak acid in its 0.2 M solution is 0.001. What is the pH?
31. What is the pH and the degree of dissociation in a 1 mM weak acid solution if its $K_a = 1.6 \times 10^{-6}$?
32. What is the pH of a 0.035 N organic amine solution if its $\text{p}K_a$ is 9.6?
33. What is the pH of a 1 w/v % acetic acid solution? $K_a = 2 \times 10^{-5}$

34. Calculate the pH of an acetate buffer containing 0.1 M acetic acid and 0.05 M sodium acetate. The pK_a of acetic acid is 4.7
35. A buffer is composed of 0.25 M ammonia and 0.5 M NH_4Cl . 20 ml 0.2 M HCl are added to 100 ml buffer. Calculate the pH change. The pK_b of ammonia is 4.7
36. How would you prepare 1 liter 50 mM buffer ($pH=7.4$) using 1 M KH_2PO_4 and 1 M K_2HPO_4 stock solutions? pK_a values of phosphoric acid are 2.1, 7.2 and 12.3, respectively.
37. 2 g NaOH will be dissolved in 1 liter 0.2 M acetic acid. What is the pH if the pK_a of acetic acid is 4.7?
38. Calculate the concentration of acetic acid and acetate ions in a 0.2 M acetate buffer ($pH=5.0$). The pK_a of acetic acid is 4.7
39. Calculate the solubility product of silver bromide if its solubility in water is 88 μM .
40. How many grams $Al(OH)_3$ can be dissolved in 1.5 liter water if its solubility product is 3.7×10^{-15} ?
41. Calculate the solubility of PbI_2 in water if its solubility product is 9×10^{-9} .
42. How many ml 1 μM NaCl should be added to 10 ml 1 mM $AgNO_3$ to initiate precipitation? The solubility product of $AgCl$ is 1.6×10^{-10} .
43. What is the electromotive force of a voltaic cell whose electrodes contain 1 N HCl and 0.02 M $MgSO_4$, respectively? $\varepsilon_{Mg}^{\circ} = -2.38$ V
44. Calculate the electromotive force of the following voltaic cell ($\varepsilon_{Mg}^{\circ} = -2.38$ V):
(Pt) H_2 / 0.1 N HCl // 0.001 M $MgSO_4$ / Mg
45. Calculate the electromotive force for the reaction of a galvanic cell consisting of the following electrodes:
Cu / 1.6 w/v% $CuSO_4$ // 0.2 M $MgSO_4$ / Mg
 $\varepsilon_{Mg}^{\circ} = -2.38$ V; $\varepsilon_{Cu}^{\circ} = +0.34$ V; the molar mass of $CuSO_4$ is 160 g/mol
46. The electromotive force of the voltaic cell below is 1.65 V. Calculate the Zn^{2+} concentration. $\varepsilon_{Ag}^{\circ} = +0.80$ V; $\varepsilon_{Zn}^{\circ} = -0.76$ V
(+) Ag / 1 M $AgNO_3$ // $ZnSO_4$ / Zn (-)
47. Calculate the $ZnSO_4$ concentration in the voltaic cell comprising a Zn^{2+}/Zn and a standard H-electrode if the electromotive force is 0.85 V. The standard potential of Zn is -0.76 V.
48. An iron plate is immersed into a $CuSO_4$ solution. In a certain time, the weight of the plate increased by 2 g. How many grams copper was reduced on the iron plate? Atomic masses are 64 for Cu and 56 for Fe.

49. What is the electromotive force of a hydrogen concentration cell consisting of 0.1 N HCl and 0.01 N acetic acid electrolytes? The pK_a of acetic acid is 4.7
50. What is the electromotive force of the following concentration cell:
 - (Pt) / H_2 / buffer (pH = 6.5) // 0.1 M valeric acid / H_2 (Pt) +
 The ionization constant of valeric acid is 1.6×10^{-5}
51. Calculate the molarity of acetic acid in the concentration cell below if the electromotive force is 0.15 V. The pK_a of acetic acid is 4.7
 - (Pt) / H_2 / acetic acid // 0.001 N HCl / H_2 (Pt) +
52. The electromotive force of a concentration cell is 0.1 V. The electrodes contain 0.1 N HCl and 0.02 N HCOOH ($pK_a = 3.7$). Calculate the pH and the degree of ionization of the formic acid.
53. A concentration cell is composed of chlorine electrodes containing 1 N and 0.0001 N HCl. Which electrode is the negative pole? What is the electromotive force? Set up equations for half-cell reactions. The standard reduction potential of chlorine is +1.36 V.
54. A concentration cell contains acetate buffer (1:1) and 0.5 M acetic acid at its hydrogen electrodes, respectively. Calculate the electromotive force. The pK_a of acetic acid is 4.7
55. What is the electrode potential of a redox electrode which contains 80% Fe^{3+} and 20% Fe^{2+} ions in 0.1 M sulfate salt solution? The standard reduction potential is +0.77 V
56. Calculate the electromotive force and the free enthalpy change for the reaction of the following cell:
 (Pt) / H_2 / $C_4H_4O_5$: $C_4H_6O_5$ (1:1) // 0.1 M HCl / H_2 / (Pt)
 The standard reduction potential of the oxaloacetate/malate electrode is -0.17 V
57. Calculate the electromotive force of a redox cell consisting of copper and iron redox electrodes. $[Cu^{2+}] = 100 [Cu^+]$; $[Fe^{2+}] = 100 [Fe^{3+}]$. Standard reduction potentials are +0.15 V for the copper and +0.77 V for the iron redox electrode, respectively. Calculate the free enthalpy change, too.
58. Calculate the enthalpy of formation of ethanol if its combustion heat is -1364.4 kJ/mol, the formation enthalpies of CO_2 and H_2O are -393.3 kJ/mol and -285.5 kJ/mol, respectively.
59. How much is the heat of formation of urea if the enthalpy of formation of ammonia is -45.8 kJ/mol and the reaction heat is +119.1 kJ?
 $H_4N_2CO_{(s)} + H_2O_{(l)} \rightarrow CO_{2(g)} + 2 NH_{3(g)}$
60. What is the enthalpy of formation of benzene (C_6H_6) if its combustion heat is -41.8 kJ/g? The formation enthalpies of CO_2 and H_2O are -393.3 kJ/mol and -285.5 kJ/mol, respectively.

61. Calculate the enthalpy of formation of acetylene (ethyne) if its combustion heat is -1300 kJ/mol. The formation enthalpies of CO₂ and H₂O are -393.3 kJ/mol and -285.5 kJ/mol, respectively.
62. Calculate the standard entropy change of the burning of sulfur if standard entropies are 167.2 J/Kmol for S, 204.8 J/Kmol for oxygen and 248.3 J/ Kmol for SO₂. Calculate the Gibbs free enthalpy change, too, if the enthalpy change during the reaction is -393 kJ/mol.
63. The equilibrium constant of the reaction below is 120. How much is the standard Gibbs free enthalpy change in this reaction? Is this reaction spontaneous or not?
$$2 \text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O} \rightarrow (\text{NH}_4)_2\text{CO}_3$$
64. In which direction is the following reaction spontaneous?
$$\text{CO} + \text{H}_2\text{O}_{(\text{g})} \rightarrow \text{CO}_2 + \text{H}_2$$

Standard free formation enthalpies are - 137.1 kJ/mol for CO, - 394 kJ/mol for CO₂, - 228 kJ/mol for water and 0 kJ/mol for hydrogen.