

## WORKSHEET - SOLUTIONS

### A. Review – Solution Concentration Calculations

- What mass, in grams, of sodium sulfate is needed to make 275 g of a 1.5% (m/m) aqueous solution of sodium sulfate? Answer: 4.1 g
- What is the molar concentration of a barium chloride solution that is prepared by adding 20.0 mL of water to 50.0 mL of a 10.0 M barium chloride solution? (Assume volumes are additive) Answer: 7.14 M
- What mass, in grams, of calcium nitrate are there in 867 mL of a 2.00 M calcium nitrate solution? (Molar mass calcium nitrate = 164.09 g/mole) Answer: 285 g
- Two sulfuric acid solutions are mixed as follows: 25.0 mL of a 0.50 M sulfuric acid solution are added to 0.075 L of a 0.25 M sulfuric acid solution. What is the molarity of the resulting mixture? (Assume volumes are additive) Answer: 0.32 M
- What is the molality of a solution made by dissolving 20.0 g silver nitrate in 225 g water? (Molar mass AgNO<sub>3</sub> = 169.87 g/mole) Answer: 0.523 m
- What is the molarity of a 2.80%(m/v) ammonia solution? (Molar mass NH<sub>3</sub> = 17.03 g/mole) Ans: 1.64 M
- What volume, in liters, of a 2.00 M KCl solution contains 2.5 g of KCl? (Molar mass KCl = 74.55 g/mole) Answer: 0.017 L solution
- A solution of ethanol, C<sub>2</sub>H<sub>6</sub>O, is prepared by dissolving 14.0 g C<sub>2</sub>H<sub>6</sub>O in 100.0 g water. (Molar mass ethanol = 46.07 g/mole)
  - Find the molality of the solution. Answers: a. 3.04 m
  - Find the % (m/m) concentration of the solution. b. 12.3% (m/m)
- What volume, in mL, of 0.250 M silver nitrate solution is needed to react with 45.0 mL of 0.187 M potassium phosphate solution? (Molar masses: AgNO<sub>3</sub> = 169.87 K<sub>3</sub>PO<sub>4</sub> = 212.27 Ag<sub>3</sub>PO<sub>4</sub> = 418.58 KNO<sub>3</sub> = 101.10)
 
$$3 \text{ AgNO}_3(\text{aq}) + \text{K}_3\text{PO}_4(\text{aq}) \longrightarrow \text{Ag}_3\text{PO}_4(\text{s}) + 3 \text{ KNO}_3(\text{aq})$$
Answer: 101 mL soln
- 76.91 mL of a 0.556 M oxalic acid solution are required to react with 28.43 mL of a sodium hydroxide solution. What is the molar concentration of the sodium hydroxide solution? (Molar masses: H<sub>2</sub>C<sub>2</sub>O<sub>4</sub> = 90.04 NaOH = 40.00 H<sub>2</sub>O = 18.02 Na<sub>2</sub>C<sub>2</sub>O<sub>4</sub> = 134.00)
 
$$\text{H}_2\text{C}_2\text{O}_4(\text{aq}) + 2 \text{ NaOH}(\text{aq}) \longrightarrow 2 \text{ H}_2\text{O}(\text{l}) + \text{Na}_2\text{C}_2\text{O}_4(\text{aq})$$
Answer: 3.01 M
- What mass, in grams, of lead (II) chromate can be produced from 12.00 mL of 10.0 M potassium chromate solution with 120.00 mL of 2.00 M lead(II) nitrate solution? (Molar masses: K<sub>2</sub>CrO<sub>4</sub> = 194.19 Pb(NO<sub>3</sub>)<sub>2</sub> = 331.21 KNO<sub>3</sub> = 101.10 PbCrO<sub>4</sub> = 323.19)
 
$$\text{K}_2\text{CrO}_4(\text{aq}) + \text{Pb}(\text{NO}_3)_2(\text{aq}) \longrightarrow 2 \text{ KNO}_3(\text{aq}) + \text{PbCrO}_4(\text{s})$$
Answer: 38.8 g
- 2.489 g of cesium oxalate are dissolved in enough water to give 265.0 mL of a solution whose density is 1.0528 g/mL. What is the percent by mass concentration of the solution? (molar mass cesium oxalate = 353.83 g/mole) Answer: 0.8921% (m/m)
- What volume, in liters, of 6.11 M NaOH solution would you need to prepare 580.0 mL of a 0.135 M NaOH solution by dilution? (molar mass NaOH = 40.00 g/mole) Answer: 0.0128 L soln
- What is the molar concentration of a 3.296 m aqueous solution of fructose? The density of the solution is 1.203 g/mL. (molar mass fructose = 180.16 g/mole) Answer: 2.488 M
- 254.6 mL of a 0.355 M cadmium borate solution is mixed with 187.3 mL of a 0.276 M cadmium borate solution. Assuming volumes are additive, what is the molar concentration of cadmium ion in the resulting solution? (molar mass: cadmium borate = 454.85 g/mole) Answer: 0.964 M Cd<sup>2+</sup>

16. The density of a 60.00 % (m/m) ethanol,  $C_2H_5OH$ , solution is 0.8937 g/mL. What is the molarity of the solution? (molar mass = 46.07 g/mole) Answer: 11.64 M
17. The density of a 2.687 M sodium acetate solution is 1.104 g/mL. What is the concentration of this solution expressed as % (m/m)  $NaC_2H_3O_2$ ? (molar mass = 82.03 g/mole) Answer: 19.97 % (m/m)
18. An aqueous solution of citric acid,  $H_3C_6H_5O_7$ , is 0.655 M and has a density of 1.049 g/mL. What is the molality of the solution? (molar mass = 192.13 g/mole) Answer: 0.710 m
19. An aqueous solution of tartaric acid,  $H_2C_4H_4O_6$ , is 0.278 m and has a density of 1.006 g/mL. What is the molarity of the solution? (molar mass = 150.09 g/mole) Answer: 0.268 M
20. Calculate the molality of a 23.0% by mass acetic acid,  $HC_2H_3O_2$ , solution. (molar mass = 60.05 g/mole) Answer: 4.97 M
21. The concentration of a  $Pb(NO_3)_2$  solution is 0.953 m and 0.907 M. What is the density of the solution, in grams per mL? (molar mass = 331.21 g/mole) Answer: 1.25 g/mL

B. New

1. Find the molar concentration of each of the ions in a solution that contains 0.165 moles of aluminum chloride in 820 mL solution. Answers: 0.201 M  $Al^{3+}$ , 0.603 M  $Cl^-$
2. Find the molar concentration of each of the ions in a solution that results from mixing 27 mL of 0.25 M  $HNO_3$  with 36 mL of 0.42 M  $Ca(NO_3)_2$ . (Assume volumes are additive.) Answers: 0.11 M  $H^+$ , 0.59 M  $NO_3^-$ , 0.24 M  $Ca^{2+}$
3. Find the molarity of each of the ions present in a solution prepared by mixing 35 mL of 0.42 M  $K_2SO_4$  with 27 mL of 0.17 M  $K_3PO_4$ . (Assume volumes are additive.) Answers: 0.71 M  $K^+$ , 0.24 M  $SO_4^{2-}$ , 0.074 M  $PO_4^{3-}$
4. Calculate the molar concentration of each ion present in solution, and the mass of any solid remaining, after the reaction that occurs when 0.300 mole of aluminum hydroxide is added to 50.0 mL of 2.5 M nitric acid solution (Assume that there is no volume change upon the addition of the aluminum hydroxide to the solution). Hint: Write a balanced equation for the reaction taking place. Answers: 0.83 M  $Al^{3+}$ , 2.5 M  $NO_3^-$ , 20 g  $Al(OH)_3$
5. A solution consists of 3.88 g benzene,  $C_6H_6$ , and 2.45 g toluene,  $C_7H_8$ . The vapor pressures of benzene and toluene at 20°C are 75 torr and 22 torr respectively. Assuming the solution behaves ideally, calculate the mole fraction of benzene in the vapor. (molar masses:  $C_6H_6$  = 78.0 g/mole;  $C_7H_8$  = 92.0 g/mole.) Answer = 0.87
6. The freezing point of an aqueous solution of glucose,  $C_6H_{12}O_6$ , is 10.3°C. The density of the solution is 1.50 g/mL. What is the molarity of the glucose solution? (molar mass glucose = 180.0 g/mole;  $K_f$  for water is 1.86°C.kg/mole) Answer: 4.16 M
7. What is the normal boiling point of a 2.70 M aqueous solution of KBr that has a density of 1.80 g/mL? ( $K_b$  for  $H_2O$  is 0.512°C kg/mole) Answer: 101.9°C
8. 28.00 mL of 0.670 M potassium carbonate solution is mixed with 15.00 mL of 0.940 M cobalt(III) chloride.
  - a. Write the molecular, total and net ionic equations for the reaction that occurs.
  - b. Identify any solid formed in the reaction and calculate its mass.
  - c. Calculate the molar concentration of each ion remaining in solution after the reaction is complete. Answers: b. 1.87 g of  $Co_2(CO_3)_3$ ; c. 0.874 M  $K^+$ , 0.0372 M  $Co^{3+}$ , 0.986 M  $Cl^-$ , 0 M  $CO_3^{2-}$

1. A solution that contains 12.6 g of a solid nonvolatile nonelectrolyte dissolved in 400 g of benzene freezes at 3.6°C. The normal freezing point of benzene is 5.5°C. What is the molar mass of the solute? ( $K_f$  for benzene is 4.96°C kg/mole) Answer: 82 g/mole
  2. Chloroform and methanol form an ideal solution. The solution boils at 22°C and 0.255 atm. At 22°C the vapor pressures of methanol and chloroform are 0.192 atm and 0.311 atm respectively. What is the mole fraction of chloroform in the solution? Answer: 0.529
  3. What is the normal boiling point of a 1.21 M aqueous solution of calcium iodide that has a density of 1.92 g/mL? ( $K_b$  for H<sub>2</sub>O is 0.512°C kg/mole) Answer: 101.2°C
  4. Calculate the freezing point of an aqueous solution that is 36.0 % by mass Na<sub>3</sub>PO<sub>4</sub>. ( $K_f$  for H<sub>2</sub>O = 1.86°C kg/mole) Answer: -25.5°C
  5. 32.00 mL of 0.311 M aluminum nitrate is mixed with 64.00 mL of 0.177 M sodium carbonate and allowed to react.
    - a. Write the molecular, total and net ionic equations for the reaction that occurs.
    - b. Identify and solid formed in the reaction and calculate its mass.
    - c. Calculate the molar concentration of each ion remaining in solution after the reaction is complete. Answers: b. 0.884 g of Al<sub>2</sub>(CO<sub>3</sub>)<sub>3</sub>   c. 0 M CO<sub>3</sub><sup>2-</sup>, 0.0252 M Al<sup>3+</sup>, 0.312 M NO<sub>3</sub><sup>-</sup>, 0.236 M Na<sup>+</sup>
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1. What is the molar concentration of an aqueous solution of C<sub>6</sub>H<sub>12</sub>O<sub>6</sub> (a nonvolatile nonelectrolyte) that has a boiling point of 101.40°C and a density of 1.68 g/mL? ( $K_b$  for H<sub>2</sub>O is 0.512°C kg/mole) Answer: 3.07 M
  2. What is the normal freezing point of a 0.6837 M aqueous solution of C<sub>12</sub>H<sub>22</sub>O<sub>11</sub> (a nonvolatile nonelectrolyte), that has a density of 1.35 g/mL? ( $K_f$  for H<sub>2</sub>O = 1.86°C kg/mole) Answer: -1.14°C
  3. Two volatile liquids, heptane, C<sub>7</sub>H<sub>16</sub>, and octane, C<sub>8</sub>H<sub>18</sub>, form an ideal solution. At 40°C the vapor pressure of pure heptane is 0.522 atm, and the vapor pressure of pure octane is 0.238 atm. A solution is prepared by mixing 5.32 g heptane and 8.80 g octane. Calculate the mole fraction of octane in the vapor above the solution. Answer: 0.398
  4. C<sub>4</sub>H<sub>2</sub>N is a nonvolatile molecular compound. When 3.84 g C<sub>4</sub>H<sub>2</sub>N is dissolved in 500 g benzene, the resulting solution has a freezing point that is 0.307°C lower than that of pure benzene. What are the molar mass and molecular formula of C<sub>4</sub>H<sub>2</sub>N? ( $K_f$  for benzene = 5.12°C kg/mole) Answers: 128 g/mole; C<sub>8</sub>H<sub>4</sub>N<sub>2</sub>
  5. Liquids A and B form an ideal solution. The vapor pressure of pure A is 0.700 atm at the normal boiling point of a solution prepared from 0.250 mole of B and 0.650 mole of A. What is the vapor pressure of pure B at this temperature? Answer: 1.77 atm
  6. A 0.900 L aqueous solution contains 30.0 g of a compound. The osmotic pressure of the solution is 12.7 torr at 25°C. What is the molar mass of the compound? Answer: 4.88 x 10<sup>4</sup> g/mole
  7. Acetone and methanol form ideal solution. At 25°C, the vapor pressures of pure acetone and pure methanol are 0.342 atm and 0.188 atm respectively. Calculate the mole fraction of methanol in a solution that boils at 25°C and 0.248 atm. Answer: 0.610