

Chemistry 30

Unit 4: Solutions

Assignment 3 Calculations involving Solution and Ion Concentrations

You must clearly show all work for your calculations. Be sure to highlight your final answer – circle it, underline it, whatever. Be sure to include the units for your answer. Failure to follow these directions will result in a loss of marks.

1. What mass of sodium hydroxide is needed to make 500.0 mL of 0.5 M NaOH solution.

$$\text{Molar Mass of NaOH} = 40.0 \text{ g}\cdot\text{mol}^{-1}$$

$$g = \frac{40.0g}{\text{mol}} \times \frac{0.5\text{mol}}{L} \times \frac{0.500L}{1} = 10.0g$$

2. What volume of 0.060 M KCl solution contains 2.39 g of KCl?

$$\text{Molar mass of KCl} = 74.6 \text{ g}\cdot\text{mol}^{-1}$$

$$L = \frac{L}{0.060\text{mol}} \times \frac{\text{mol}}{74.6g} \times \frac{2.39g}{1} = 0.53L \text{ or } 530 \text{ mL}$$

3. Calculate the concentration of a solution prepared by dissolving 24.2 g of $\text{Fe}_2(\text{SO}_4)_3$ in enough water to make 250.0 mL of solution.

$$\text{Molar mass of Fe}_2(\text{SO}_4)_3 = 399.9 \text{ g}\cdot\text{mol}^{-1}$$

$$M = \frac{\text{mol}}{L} = \frac{\text{mol}}{399.9g} \times \frac{24.2g}{1} \times \frac{1}{0.250L} = 0.242M$$

4. What is the concentration of a solution prepared by dissolving 6.1 g of KSCN in enough water to make 500.0 mL of solution?

Molar mass of KSCN = 97.1 g·mol⁻¹

$$M = \frac{\text{mol}}{\text{L}} = \frac{\text{mol}}{97.1\text{g}} \times \frac{1}{0.500\text{L}} \times \frac{6.1\text{g}}{1} = 0.13\text{M}$$

5. Describe how to prepare 250 mL of a standard 5.00 M KNO₃ solution. Be sure to identify any special lab equipment required. Show all calculations.

This question will require you to find the mass of KNO₃ that must be used to prepare 250 mL of solution:

molar mass KNO₃ = 101.1 g·mol⁻¹

$$g = \frac{101.1\text{g}}{\text{mol}} \times \frac{5.00\text{mol}}{\text{L}} \times \frac{0.250\text{L}}{1} = 126\text{g}$$

How to prepare the solution – mass out 126 g of KNO₃ and dissolve that in some distilled water. Place this solution in a 250 mL volumetric flask. Using distilled water, fill the flask to the line marked on the flask.

6. Determine the volume of solution that contains 80.0 g of 2.00 M copper(II) nitrate.

molar mass of Cu(NO₃)₂ = 187.5 g·mol⁻¹

$$L = \frac{80.0\text{g}}{1} \times \frac{\text{mol}}{187.5\text{g}} \times \frac{\text{L}}{2.00\text{mol}} = 0.213\text{L} = 213\text{mL}$$

7. A student adds enough water to 120 mL of a 6.0 M solution of NaOH until the final volume of the solution is 2.0 L. What is the concentration of the diluted solution?

This is a dilution question – use the formula $M_1V_1 = M_2V_2$

$$M_1 = 6.0 \text{ M}$$

$$M_2 = M_2$$

$$V_1 = 0.120 \text{ L}$$

$$V_2 = 2.0 \text{ L}$$

be sure units for volume are the same!

$$M_1V_1 = M_2V_2$$

$$(6.0)(0.120) = M_2(2.0)$$

$$\frac{0.72}{2.0} = M_2$$

$$M_2 = 0.36 \text{ M}$$

The concentration of the dilute solution is 0.36M

8. What volume of a 18.0 M H_2SO_4 solution is required to make 2.5 L of a 1.0 M H_2SO_4 solution?

This is a dilution question – use the formula $M_1V_1 = M_2V_2$

$$M_1 = 18.0 \text{ M}$$

$$M_2 = 1.0$$

$$V_1 = V_1$$

$$V_2 = 2.5 \text{ L}$$

$$M_1V_1 = M_2V_2$$

$$(18.0)(V_1) = (1.0)(2.5)$$

$$V_1 = \frac{2.5}{18.0}$$

$$V_1 = 0.139 \text{ L} \text{ or } 139 \text{ mL are required}$$

9. What mass of ammonium chloride, NH_4Cl , is present in 0.30 L of a 0.40 M NH_4Cl solution?

molar mass of $\text{NH}_4\text{Cl} = 53.5 \text{ g}\cdot\text{mol}^{-1}$

$$g = \frac{53.5g}{mol} \times \frac{0.40mol}{L} \times \frac{0.30L}{1} = 6.42g \text{ is present}$$

10. A chemist evaporates 25.0 mL of NaCl solution to dryness and finds 0.585 g of NaCl. What was the molarity of the original solution?

$$\text{Molar mass of NaCl} = 58.5 \text{ g}\cdot\text{mol}^{-1}$$

$$M = \frac{\text{mol}}{\text{L}} = \frac{\text{mol}}{58.5\text{g}} \times \frac{0.585\text{g}}{1} \times \frac{1}{0.025\text{L}} = \frac{0.400\text{mol}}{\text{L}}$$

11. What is the concentration of an ammonia solution prepared by diluting 75.00 mL solution of concentrated ammonia, NH_3 (14.8 M) to a volume of 2.000 L.

$$M_1 = 14.8$$

$$M_2 = M_2$$

$$V_1 = 0.075 \text{ L}$$

$$V_2 = 2.000 \text{ L}$$

be sure units for volume are the same

$$M_1V_1 = M_2V_2$$

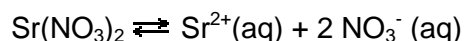
$$(14.8)(0.075) = M_2(2.00)$$

$$M_2 = \frac{1.11}{2}$$

$$M_2 = 0.555 \text{ M}$$

12. Calculate the concentrations **of the ions** in the following solutions. Be sure to write a balanced equation for each dissociation reaction. You MUST remember to include proper ion charges for all ions! The first equation is shown for you.

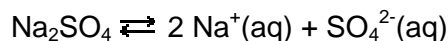
- a) an aqueous solution containing 0.075 M strontium nitrate, $\text{Sr}(\text{NO}_3)_2$



$$[\text{Sr}^{2+}] = [\text{Sr}(\text{NO}_3)_2] = 0.075 \text{ M}$$

$$[\text{NO}_3^{-}] = 2 \times [\text{Sr}(\text{NO}_3)_2] = 2 \times 0.075 \text{ M} = 0.15 \text{ M}$$

- b) a 0.15 M solution of sodium sulfate, Na_2SO_4



$$[\text{SO}_4^{2-}] = [\text{Na}_2\text{SO}_4] = 0.15 \text{ M}$$

$$[\text{Na}^{+}] = 2 \times [\text{Na}_2\text{SO}_4] = 2 \times 0.15 = 0.30 \text{ M}$$

c) a 2.000 L aqueous solution containing 107.0 g ammonium chloride, NH_4Cl

Hint: Begin by calculating the concentration of the NH_4Cl solution.

molar mass of $\text{NH}_4\text{Cl} = 53.5 \text{ g}\cdot\text{mol}^{-1}$

$$M = \frac{\text{mol}}{\text{L}} = \frac{\text{mol}}{53.5\text{g}} \times \frac{107.0\text{g}}{1} \times \frac{1}{2.000\text{L}} = \frac{1.00\text{mol}}{\text{L}} = 1.00\text{M} = [\text{NH}_4\text{Cl}]$$

Write the balanced equation: $\text{NH}_4\text{Cl} \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{Cl}^-(\text{aq})$

$$[\text{NH}_4^+] = [\text{NH}_4\text{Cl}] = 1.00 \text{ M}$$

$$[\text{Cl}^-] = [\text{NH}_4\text{Cl}] = 1.00 \text{ M}$$

d) 250.0 mL solution containing 25.50 g of sodium phosphate

Hint: Be sure to write the correct chemical formula for sodium phosphate. Then determine the concentration of the sodium phosphate solution. Write a balanced dissociation equation in order to next determine the concentration of the ions in solution.

sodium phosphate = Na_3PO_4

molar mass of $\text{Na}_3\text{PO}_4 = 164.0 \text{ g}\cdot\text{mol}^{-1}$

$$M = \frac{\text{mol}}{\text{L}} = \frac{\text{mol}}{164.0\text{g}} \times \frac{25.5\text{g}}{1} \times \frac{1}{0.250\text{L}} = 0.622\text{M} = [\text{Na}_3\text{PO}_4]$$

The balanced equation: $\text{Na}_3\text{PO}_4 \rightleftharpoons 3 \text{Na}^+(\text{aq}) + \text{PO}_4^{3-}(\text{aq})$

$$[\text{Na}^+] = 3 \times [\text{Na}_3\text{PO}_4] = 3 \times 0.622 = 1.87 \text{ M}$$

$$[\text{PO}_4^{3-}] = [\text{Na}_3\text{PO}_4] = 0.622 \text{ M}$$