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.

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

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

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

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

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

3. Calculate the concentration of a solution prepared by dissolving 24.2 g of $Fe_2(SO_4)_3$ in enough water to make 250.0 mL of solution.

   Molar mass of $Fe_2(SO_4)_3$ = 399.9 $g \cdot mol^{-1}$

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

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}

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

5. Describe how to prepare 250 mL of a standard 5.00 M KNO_3 solution. Be sure to identify any special lab equipment required. Show all calculations.

   This question will require you to find the mass of KNO_3 that must be used to prepare 250 mL of solution:

   molar mass KNO_3 = 101.1 g·mol^{-1}

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

   How to prepare the solution – mass out 126 g of KNO_3 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 $Cu(NO_3)_2$ = 187.5 g·mol^{-1}

$$L = \frac{80.0g}{1} \times \frac{mol}{1876.5g} \times \frac{L}{2.00mol} = 0.213L = 213mL$$

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 $M_1V_1 = M_2V_2$

$M_1 = 6.0$ M $\qquad M_2 = M_2$

$V_1 = 0.120$ L $\qquad V_2 = 2.0$ L $\qquad$ **be sure units for volume are the same!**

$M_1V_1 = M_2V_2$

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

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

$M_2 = 0.36$ M $\qquad$ **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 $M_1V_1 = M_2V_2$

$M_1 = 18.0$ M $\qquad M_2 = 1.0$

$V_1 = V_1 \qquad V_2 = 2.5$ L

$M_1V_1 = M_2V_2$

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

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

$V_1 = 0.139$ L or 139 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 $NH_4Cl = 53.5$ g·mol^{-1}

$$g = \frac{53.5g}{mol} \times \frac{0.40mol}{L} \times \frac{0.30L}{1} = 6.42g$$ 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?

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

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

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.

$M_1 = 14.8$ $M_2 = M_2$

$V_1 = 0.075$ L $V_2 = 2.000$ L be sure units for volume are the same

$M_1V_1 = M_2V_2$

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

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

$M_2 = 0.555$ 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, $Sr(NO_3)_2$

$Sr(NO_3)_2 \rightleftarrows Sr^{2+}(aq) + 2\ NO_3^-(aq)$

$[Sr^{2+}] = [Sr(NO_3)_2] = 0.075$ M

$[NO_3^-] = 2 \times [Sr(NO_3)_2] = 2 \times 0.075$ M $= 0.15$ M

b) a 0.15 M solution of sodium sulfate, Na_2SO_4

$Na_2SO_4 \rightleftarrows 2\ Na^+(aq) + SO_4^{2-}(aq)$

$[SO_4^{2-}] = [Na_2SO_4] = 0.15$ M

$[Na^+] = 2 \times [Na_2SO_4] = 2 \times 0.15 = 0.30$ 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 NH_4Cl = 53.5 g·mol^{-1}

$$M = \frac{mol}{L} = \frac{mol}{53.5g} \times \frac{107.0g}{1} \times \frac{1}{2.000L} = \frac{1.00mol}{L} = 1.00M \quad = [NH_4Cl]$$

Write the balanced equation: $NH_4Cl \rightleftarrows NH_4^+(aq) + Cl^-(aq)$

$[NH_4^+] = [NH_4Cl] = 1.00$ M

$[Cl^-] = [NH_4Cl] = 1.00$ 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 Na_3PO_4 = 164.0 g·mol^{-1}

$$M = \frac{mol}{L} = \frac{mol}{164.0g} \times \frac{25.5g}{1} \times \frac{1}{0.250L} = 0.622M = [Na_3PO_4]$$

The balanced equation: $Na_3PO_4 \rightleftarrows 3\ Na^+(aq) + PO_4^{3-}(aq)$

$[Na^+] = 3 \times [Na_3PO_4] = 3 \times 0.622 = 1.87$ M

$[PO_4^{3-}] = [Na_3PO_4] = 0.622$ M