SOLUTION STOCHIOMETRY

1. Calculate the concentration in parts per million of the following solutions:

   (a) 1.0 g of Zn dissolved in HCl and diluted to 500 mL with distilled water

   $\frac{1.0\ g}{500\ mL} = \frac{1000\ mg}{0.500\ L} = 2000\ ppm$

   (b) 0.001 g of Pb dissolved in HCl and diluted to 100 mL with distilled water.

   $\frac{0.001\ g}{100\ mL} = \frac{1\ mg}{0.10\ L} = 10\ ppm$

   (c) 0.5 g of Ag dissolved in 10mL HNO_3 and diluted to 250 mL.

   $\frac{0.05\ g}{250\ mL} = \frac{50\ mg}{0.250\ L} = 200\ ppm$

2. What mass of $CaCl_2.2H_2O$ is required to prepare 250 mL of a 500 ppm Ca solution?

   500 ppm = 500 mg per 1L

   = 0.5 g per 1000 mL

   = 0.125 g per 250 mL

   % Ca in $CaCl_2.2H_2O$ = MM Ca/MM $CaCl_2.2H_2O \times 100$

   = 40.08 g mol^{-1}/147.02 g $mol^{-1} \times 100$

   = 27.26 %

   0.125 g = 27.26 % by Ca

   (x) g = 100 % by Ca

   (x) g = 0.4585 g.

   To prepare 250 mL of a 500 ppm, accurately weigh out 0.4585 g of $CaCl_2.2H_2O$ salt, dissolve in water and make up to 250 mL with deionized water.

3. What is the concentration of Cr (in ppm) when 0.8 g of Cr_2O_3 was dissolved and made up to 750 mL?

% Cr in Cr_2O_3 = 2x MM Cr/ MM Cr_2O_3 × 100

= (52 g mol^{-1} x 2)/152 g mol^{-1} × 100 = 68.45 %

Mass of Cr in Cr_2O_3 = 0.6845 x 0.8 g = 0.5476 g

0.5476g per 750 mL = 547.6 mg/0.750 L = 730.13 ppm

4. The label on a reagent bottle containing Manganese had the following information:

1.0 g Mn/100 mL

1000 mg/100 mL = 1000 mg/0.1 L = 10 000 ppm Mn solution

Purity of Mn 99.99%

Vol of solution = 500mL

What volume of this solution is required to prepare 100 mL of the following?

(a) 1000 ppm Mn solution

10 000 ppm Mn stock × (x) = 1000 ppm × 100 mL

(x) = 0.10 mL

(b) 100 ppm Mn solution

10 000 ppm Mn stock × (x) = 100 ppm × 100 mL

(x) = 1 mL

(c) 10 ppm Mn solution

10 000 ppm Mn stock × (x) = 10 ppm × 100 mL

(x) = 10 mL

5. A solution of copper sulphate is labeled 0.1000 mol dm^{-3}. How many milliliters of this solution contains 4.25 g of $CuSO_4$?

$$M = \frac{mass\ of\ salt(g)}{MM\ of\ salt\ (g\ mol^{-1})}\ x\ \frac{1}{vol(dm^3)}$$

$$\text{Volume}(dm^3) = \frac{mass\ of\ salt}{Molarity\ x\ MM\ of\ salt} = \frac{4.25\ g}{0.1000\ M\ x\ 161.61\ g\ mol^{-1}} = 0.263\ dm^3$$

$= 0.263\ dm^3 \times 1000 =$ **263 mL**

6. (a) What is the molar concentration of concentrated H_2SO_4 that contains 96% (m/m) H_2SO_4 and has density of 1.84 g/mL?

(b) What volume of the above solution is required to make 20 dm^3 of a 0.100 M H_2SO_4 solution?

7. Describe using a calculation how you would prepare 250 mL of a 1.5 M NaCl (molar mass 58.44 g mol^{-1}) using pure solid NaCl.

Mass of NaCl = Molarity(mol dm^{-3}) × MM (g mol^{-1}) × vol (dm^3)

$= 1.5\ mol\ dm^{-3} \times 58.44\ g\ mol^{-1} \times 0.250\ dm^3$

$= 21.92\ g$

Accurate weight out 21.92 g of NaCl salt, dissolve in deionized water and make up to 250 mL with deionized water in a volumetric flask

8. A solution prepared by dissolving solid $Mg(OH)_2$ was neutralized with 50 mL of 0.0950M HCl.

(a) Give a balanced equation for the reaction.

$Mg(OH)_2(s) + 2HCl \rightarrow MgCl_2(aq) + 2H_2O(\ell)$

(b) Give the stoichiometries for all species involved.

$$\frac{\text{nMg(OH)}_2}{1} = \frac{\text{nHCl}}{2} = \frac{\text{nMgCl}_2}{1}$$

(c) What mass of $Mg(OH)_2$ is required to neutralize the HCl?

$$\frac{\text{nMg(OH)}_2}{1} = \frac{\text{nHCl}}{2} = \frac{0.0950\ M\ x\ 50\ mL}{2}$$

= 2.375 millimoles (note vol in mL)

No of millimols of $Mg(OH)_2$ = 2.375 mmols (= 0.002375 mols)

Mass of $Mg(OH)_2$ needed to neutralize HCl = 2.375 mmols × MM $Mg(OH)_2$

= 2.375 mmols × 58.33 g mol^{-1}

= 138.53 mg

= 0.1385 g

9. How many mL of 0.250M $Cr_2(SO_4)_2$ solution are needed to react completely with 300 mL of a 0.400 M $BaCl_2$ solution according to the given equation?

$$Cr_2(SO_4)_2\ (aq) + 3BaCl_2\ (aq) \rightarrow BaSO_4(s) + 3CrCl_3$$

10. A sample of seashell (made up mainly of $CaCO_3$) of mass 0.1265 g was treated with 50.0 mL of 0.1002 M HCl solution. The excess unreacted HCl required 30.75 mL of a 0.09959M NaOH for complete neutralization, calculate the percentage (%) $CaCO_3$ in the sample.

BACK-TITRATION PROBLEM

1. Write a balanced equation

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(\ell)$

2. Calculated no of mols of HCl that reacted with $CaCO_3$

No of mmols HCl added initially = 0.1002 M x 50 mL = 5.010 mmols

No of mmols NaOH added (= HCl remaining) = 0.09959 M x 30.75 mL = 3.062 mmols

No of mols of HCl that reacted with CaCO = 5.010 mmols – 3.062 mmols = **1.948 mmols**

3. From stoichiometry:

$$\frac{nCaCO_3}{1} = \frac{nHCl}{2}$$

$nCaCO_3$ = 1.948mmols/2 = 0.974 mmols

mass of $CaCO_3$ = 0.974 mmols x 100 g mol^{-1} = 97.40 mg = 0.09740 g

$$\% CaCO_3 = \frac{0.09740\ g}{0.1265\ g}\ x\ 100$$

= 76.99 %