# Mole Concept, Back-titration, and Stoichiometry problems

*You should be able to do these problems without a calculator.*

1) A 2.00 g impure sample of MgO (molar mass 40.3 grams) was completely dissolved in 50.0 mL of 1.000 M $H_2SO_4$. The excess acid was back-titrated with 25.0 mL of 0.800 M NaOH. Calculate the percent purity of the MgO sample. **[80.6 %]**

   $MgO(s) + H_2SO_4(aq) \longrightarrow MgSO_4(aq) + H_2O(l)$

2) A sample of $BaCO_3$ (MM=197.3 g) has 20.00 mL of 0.250 M HCl added to it. A back-titration of the excess HCl required 20.00 mL of 0.1500 M NaOH. Determine the mass of the original sample of $BaCO_3$. **[0.1973 g]**

   $BaCO_3(s) + 2HCl(aq) \longrightarrow BaCl_2(aq) + H_2O(l) + CO_2(g)$

3) In an analysis of $M_2CO_3 \cdot 3H_2O$, 40.00 mL of 2.000 M HCl was added to 7.597 g of the sample. A total of 40.00 mL of 1.000 M KOH was required to neutralize the excess acid. Calculate the molar mass of the hydrate and identify M. **[379.9 g/mol, metal is Cs]**

4) A sample of a sulphide of a metal M (formula $M_aS_b$) is analyzed. The sulphur in the sample is recovered as 120 mL of 0.250 M $Na_2S$ solution. The metal in the sample is recovered as 40.0 mL of 0.500 M solution of the metal. If the molar mass of the metal sulphide is 150 grams, determine the formula of the sulphide and identify the metal. **[$Al_2S_3$]**

5) A sample of solid sodium sulphite ($Na_2SO_3 \cdot XH_2O$) of mass 0.4322 g was dissolved in water and oxidized to sodium sulphate by adding exactly 0.8000 g of $I_2$.

   $I_2(aq) + SO_3^{-2}(aq) + H_2O(l) \longrightarrow 2I^{-1}(aq) + SO_4^{-2}(aq) + 2H^{+}(aq)$

   The resulting solution was then neutralized by the addition of exactly 40.00 mL of 0.100 M NaOH. Calculate the value of X. **[5]**

6) Calculate the molarity of the solution prepared by dissolving 6.00 g of NaOH in enough water to make 250.0 mL of solution. **[0.600 M]**

7) Calculate the molarity of NaOH if 10.00 mL of the solution from the previous question is diluted to a total volume of 60.00 mL. **[0.100 M]**

8) How many grams of $NH_4C_2H_3O_2$ (molar mass 77.0 grams) are needed to make 750.0 mL of 0.666 M $NH_4C_2H_3O_2$ solution? **[38.5 g]**

9) What is the molarity of the solution formed by mixing 25.0 mL of 0.500 M NaCl solution with 75.0 mL of 0.666 M NaCl solution? **[0.625 M]**

10) How many millilitres of 0.0500 M $Ba(OH)_2$ are needed to react with 40.00 mL of 0.0750 M HCl? **[30.00 mL]**

11) A 10.00 mL sample of vinegar, an aqueous solution of acetic acid ($HC_2H_3O_2$, molar mass 60.0 grams) is titrated with 0.500 M NaOH. 15.00 mL of NaOH is required to reach the end point. If the density of vinegar is 1.00 g/mL, what is the mass percent of acetic acid in the vinegar? **[4.50 %]**

12) By titration 25.00 mL of 0.100 M NaOH is required to neutralize 0.1500 g of an unknown organic acid. What is the molar mass of the acid? You may assume that the acid is monoprotic. **[60.0 g]**

13) A 0.4861 g sample of metal was dissolved in 50.00 mL of 1.000 M HCl. After all the metal had dissolved, the leftover acid was titrated with 0.4000 M NaOH. If 25.00 mL of 0.4000 M NaOH were required to neutralize the leftover acid, what was the molar mass of the metal? The metal dissolved to form $M^{+2}$ ions in solution. **[24.3 g]**

14) A piece of $CaCO_3$ (molar mass 100. grams) reacts with 2.00 L of 2.50 M HCl. After dissolution of the $CaCO_3$, a 25.00 mL sample of the remaining HCl(aq) is withdrawn and titrated with 12.50 mL of 1.000 M NaOH. What must have been the mass of the piece of $CaCO_3$? **[200 g]**

15) An iron ore sample weighing 558.5 mg is dissolved in HCl(aq) and iron is obtained as $Fe^{+2}$. This solution is then titrated with 25.00 mL of 0.02000 M $K_2Cr_2O_7$(aq). What is the % Fe by mass in the ore sample? **[30.00]**

$$6Fe^{+2}(aq) + 14H^{+}(aq) + Cr_2O_7^{-2}(aq) \longrightarrow 6Fe^{+3}(aq) + 2Cr^{+3}(aq) + 7H_2O(l)$$

16) A 10.00 gram sample of a mixture of $CaCO_3$(s) (molar mass 100. grams) and $KHCO_3$(s) (molar mass 100. grams) was heated and the two compounds decomposed. The decomposition yielded 90 mmol of $CO_2$ and 10 mmol of $H_2O$. What percentage of the original mixture was $CaCO_3$? **[80.0]**

$$CaCO_3(s) \longrightarrow CaO(s) + CO_2(g)$$
$$2KHCO_3(s) \longrightarrow H_2O(g) + CO_2(g) + K_2CO_3(s)$$

17) A mixture of $Na_2O$ (molar mass 62.0 grams) and BaO (molar mass 153.3 grams) that has a mass of 5.00 g is treated with dilute $H_2SO_4$. Barium sulphate, $BaSO_4$, precipitates from the solution, but sodium sulphate, $Na_2SO_4$, is soluble and remains in solution. The $BaSO_4$ (molar mass 233.3 grams) is collected by filtration and is dried and found to weigh 4.667 g. What percent of the original sample is BaO? **[61.3]**

18) A mixture of aluminum and zinc containing a total of 150 mmol of the two metals was completely dissolved in acid to give 3.92 L of hydrogen gas measured at STP. (1 mol of gas = 22.4 L at STP) What was the mole fraction of aluminum in the original mixture? **[1/3]**

$2Al(s) + 6H^{+}(aq) \longrightarrow 3H_2(g) + 2Al^{+3}(aq)$
$Zn(s) + 2H^{+}(aq) \longrightarrow H_2(g) + Zn^{+2}(aq)$

19) A mixture of 10.00 mL of $H_2SO_4$ and 30.00 mL of HCl required 20.00 mL of 2.500 M NaOH for complete reaction. When 30.00 mL of $H_2SO_4$ and 10.00 mL of HCl were used, 28.00 mL of 2.500 M NaOH were required. What were the concentrations of the acids? **[Both were 1.000 M]**

$H_2SO_4(aq) + 2NaOH(aq) \longrightarrow Na_2SO_4(aq) + 2H_2O(l)$
$HCl(aq) + NaOH(aq) \longrightarrow NaCl(aq) + H_2O(l)$