***Chemistry***

**4: Stoichiometry of Chemical Reactions**

**4.5: Quantitative Chemical Analysis**

79. Titration of a 20.0-mL sample of acid rain required 1.7 mL of 0.0811 *M* NaOH to reach the end point. If we assume that the acidity of the rain is due to the presence of sulfuric acid, what was the concentration of sulfuric acid in this sample of rain?

Solution

The balanced equation is



The steps to follow in solving this problem if we use volumes in milliliters are





81. In a common medical laboratory determination of the concentration of free chloride ion in blood serum, a serum sample is titrated with a Hg(NO3)2 solution.



What is the Cl– concentration in a 0.25-mL sample of normal serum that requires 1.46 mL of

8.25  10–4*M* Hg(NO3)2(*aq*) to reach the end point?

Solution

In this exercise, the volume is left in units of milliliters and the number of moles is expressed in units of millimoles to compensate for the factor of 1000 difference between units. This technique is often useful in calculations. The steps involved in solving the problem are









83. A sample of gallium bromide, GaBr3, weighing 0.165 g was dissolved in water and treated with silver nitrate, AgNO3, resulting in the precipitation of 0.299 g AgBr. Use these data to compute the % Ga (by mass) GaBr3.

Solution

The reaction is .

Begin by considering the definition of mass percentage:



Computing this concentration will require the following approach:



Using the provided data yields



Finally, the gallium mass percentage is calculated as



85. A 0.025-g sample of a compound composed of boron and hydrogen, with a molecular mass of ~28 amu, burns spontaneously when exposed to air, producing 0.063 g of B2O3. What are the empirical and molecular formulas of the compound.

Solution

Calculate the mass of B in the 0.063-gsample of B2O3. The difference of the mass of this boron and the 0.025-g sample of boron and hydrogen gives the mass of the hydrogen present. Determine the moles of B and H in the sample. Divide by the smaller number of moles to find the empirical formula. Divide the mass of the empirical formula into the assumed molecular mass of ~28 amu. That number multiplied by the subscripts of the empirical formula gives the molecular formula.



Because of rounding errors, this calculation gives a ratio of 1:3. Therefore, the empirical formula is BH3, which has a molecular mass of ~13.8 amu. Multiplication of this value by 2 gives 27.6 amu, a number of very close to the approximate mass. Consequently, the molecular formula is B2H6.

87. What volume of 0.600 *M* HCl is required to react completely with 2.50 g of sodium hydrogen carbonate?



Solution

Convert the mass of NaHCO3 to moles of Na2CO3, find the moles of HCl required to react with this number of moles of NaHCO3, and find the volume of the solution of HCl that contains the required number of moles of HCl: 49.6 mL

89. What volume of a 0.3300-*M* solution of sodium hydroxide would be required to titrate 15.00 mL of 0.1500 *M* oxalic acid?



Solution

Find the number of moles of oxalic acid contained in 15.0 mL of its solution, find the moles of NaOH required to react with this number of moles of oxalic acid, and find the volume of the solution of NaOH that contains the required number of moles of NaOH: 13.64 mL

91. A sample of solid calcium hydroxide, Ca(OH)2, is allowed to stand in water until a saturated solution is formed. A titration of 75.00 mL of this solution with 5.00  10–2 *M* HCl requires 36.6 mL of the acid to reach the end point.



The molarity? What is the solubility of Ca(OH)2 in grams per liter of solution?

Solution





93. How many milliliters of a 0.1500-*M* solution of KOH will be required to titrate 40.00 mL of a 0.0656-*M* solution of H3PO4?



Solution





95. The reaction of WCl6 with Al at ~400 °C gives black crystals of a compound containing only tungsten and chlorine. A sample of this compound, when reduced with hydrogen, gives 0.2232 g of tungsten metal and hydrogen chloride, which is absorbed in water. Titration of the hydrochloric acid thus produced requires 46.2 mL of 0.1051 *M* NaOH to reach the end point. What is the empirical formula of the black tungsten chloride?

Solution

The general solution follows these steps: and 

For Cl:



For W:



Then,



The empirical formula is WCl4.

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