AP Free Response (Unit 1)

1. A sample of dolomitic limestone containing only CaCO3 and MgCO3 was analyzed.

(a) When a 0.2800 gram sample of this limestone was decomposed by heating, 75.0 milliliters of CO2 at 750 mm Hg and 20C were evolved. How many grams of CO2 were produced.

(b) Write equations for the decomposition of both carbonates described above.

(c) It was also determined that the initial sample contained 0.0448 gram of calcium. What percent of the limestone by mass was CaCO3?

(d) How many grams of the magnesium-containing product were present in the sample in (a) after it had been heated?

2. Water is added to 4.267 grams of UF6. The only products are 3.730 grams of a solid containing only uranium, oxygen and fluorine and 0.970 gram of a gas. The gas is 95.0% fluorine, and the remainder is hydrogen.

(a) From these data, determine the empirical formula of the gas.

(b) What fraction of the fluorine of the original compound is in the solid and what fraction in the gas after the reaction?

(c) What is the formula of the solid product?

(d) Write a balanced equation for the reaction between UF6 and H2O. Assume that the empirical formula of the gas is the true formula.

3. Three volatile compounds X, Y, and Z each contain element Q. The percent by weight of element Q in each compound was determined. Some of the data obtained are given below.

Percent by weight Molecular

Compound of Element Q Weight

X 64.8% ?

Y 73.0% 104.

Z 59.3% 64.0

(a) The vapor density of compound X at 27°C and 750. mm Hg was determined to be 3.53 grams per litre. Calculate the molecular weight of compound X.

(b) Determine the mass of element Q contained in 1.00 mole of each of the three compounds.

(c) Calculate the most probable value of the atomic weight of element Q.

(d) Compound Z contains carbon, hydrogen, and element Q. When 1.00 gram of compound Z is oxidized and all of the carbon and hydrogen are converted to oxides, 1.37 grams of CO2 and 0.281 gram of water are produced. Determine the most probable molecular formula of compound Z.

4. Answer the following questions that relate to the analysis of chemical compounds.

(a) A compound containing the elements C, H, N, and O is analyzed. When a 1.2359 g sample is burned in excess oxygen, 2.241 g of CO2*(g)* is formed. The combustion analysis also showed that the sample contained 0.0648 g of H.

(i) Determine the mass, in grams, of C in the 1.2359 g sample of the compound.

(ii) When the compound is analyzed for N content only, the mass percent of N is found to be 28.84 percent. Determine the mass, in grams, of N in the original 1.2359 g sample of the compound.

(iii) Determine the mass, in grams, of O in the original 1.2359 g sample of the compound.

(iv) Determine the empirical formula of the compound.

5. Answer the following questions relating to gravimetric analysis.

In the first of two experiments, a student is assigned the task of determining the number of moles of water in one mole of MgCl2 *n* H2O. The student collects the data shown in the following table.

|  |  |
| --- | --- |
| Mass of empty container | 22.347 g |
| Initial mass of sample and container | 25.825 g |
| Mass of sample and container after first heating | 23.982 g |
| Mass of sample and container after second heating | 23.976 g |
| Mass of sample and container after third heating | 23.977 g |

* 1. Explain why the student can correctly conclude that the hydrate was heated a sufficient number of times in the experiment.
  2. Use the data above to
     1. calculate the total number of moles of water lost when the sample was heated, and
     2. determine the formula of the hydrated compound.
  3. A different student heats the hydrate in an uncovered crucible, and some of the solid spatters out of the crucible. This spattering will have what effect on the calculated mass of the water lost by the hydrate? Justify your answer.

In the second experiment, a student is given 2.94 g of a mixture containing anhydrous MgCl2 and KNO3 . To determine the percentage by mass of MgCl2 in the mixture, the student uses excess AgNO3(*aq*) to precipitate the chloride ion as AgCl(*s*).

* 1. Starting with the 2.94 g sample of the mixture dissolved in water, briefly describe the steps necessary to quantitatively determine the mass of the AgCl precipitate.
  2. The student determines the mass of the AgCl precipitate to be 5.48 g. On the basis of this information, calculate each of the following.
     1. The number of moles of MgCl2 in the original mixture
     2. The percent by mass of MgCl2 in the original mixture