2.4 INVESTIGATION: PERCENTAGE COMPOSITION BY MASS OF MAGNESIUM OXIDE

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Prediction

(a) According to the chemical formula and the molar masses, the mass of one mole of magnesium oxide, $MgO_{(s)}$, is 40.61 g. The percentage composition is 60.31% magnesium and 39.69% oxygen.

$$\% \text{ Mg} = \frac{24.31 \cancel{\text{g}}}{40.31 \cancel{\text{g}}} \times 100\%$$

$$\% \text{ Mg} = 60.31\%$$

$$\% \text{ O} = \frac{16.00 \cancel{\text{g}}}{40.31 \cancel{\text{g}}} \times 100\%$$

$$\% \text{ O} = 39.69\%$$

Observations

mass of a clean, dry crucible and lid = 38.46 g
mass of crucible, lid, and 7.5-cm strip of $Mg_{(s)}$ = 38.55 g
mass of crucible, lid, and product = 38.62 g

– slight darkening of shiny magnesium while heating
– after heating strongly, a white flame was observed
– initial product was white with noticeable dark areas
– mixing with water produced a grey, cloudy mixture
– final solid was slightly grey in appearance

Analysis

(b) The red coating on the aluminum strip formed when it was placed in the solution, which indicated that a chemical reaction occurred. The flame also indicated that a chemical reaction occurred.

(c) The contents of the crucible were crushed with a stirring rod in step 8 and reheated in step 9 to improve the percentage yield of the product.

(d) m_{Mg} = 38.55 g – 38.46 g
m_{Mg} = 0.09 g
m_{product} = 38.62 g – 38.46 g
m_{product} = 0.16 g
m_{O} = 0.16 g – 0.09 g
m_{O} = 0.07 g

The mass of oxygen that reacted with the magnesium is 0.07 g.

(e) $$\% \text{ Mg} = \frac{0.09 \cancel{\text{g}}}{0.16 \cancel{\text{g}}} \times 100\%$$

$$\% \text{ Mg} = 56\%$$

$$\% \text{ O} = \frac{0.07 \cancel{\text{g}}}{0.16 \cancel{\text{g}}} \times 100\%$$

$$\% \text{ O} = 44\%$$

According to the evidence from this experiment and others, the percentage composition of magnesium oxide is between 50% and 60% magnesium, and between 40% and 50% oxygen. It is not possible to tell if this percentage is very constant.

Evaluation

(f) If some of the magnesium oxide had escaped from the crucible, the mass of the product left in the crucible would be less than the Prediction. The mass of magnesium would not be affected, however. Therefore, the percentage composition of magnesium would be too high.

(g) If the other component of air is nitrogen, the percentage composition of magnesium would be higher than the Prediction. Nitrogen has a lower molar mass than oxygen. Also, the formula of magnesium nitride, Mg_3N_2, means that the ratio of magnesium to nitrogen is 1 : 0.67 versus 1:1 for magnesium oxide. Therefore, the mass of product would be less for the same mass of magnesium and the percentage composition would be higher than the predicted value.

(h) Magnesium metal, like many metals, oxidizes in air to form an oxide layer. The oxide layer needs to be removed to more accurately determine the mass of pure magnesium.

(i) The best modification would be to cause the magnesium to react inside a container of pure oxygen. This method would require a substantial modification to the materials and procedure, however.

(j) The Prediction is inconclusive because the certainty of the experimental answer is only one significant digit. The accuracy of the balance is probably one or two hundredths of a gram. Therefore, the answer can vary widely. The law of definite proportions remains valid until it is tested with an improved experiment.

Synthesis

(k) Some of the educational requirements to become a gemologist include courses such as Diamonds, Diamond Grading, Coloured Stones, Coloured Stone Grading, and Gem Identification. A Math and Science background, liberal arts education, and the knowledge of foreign languages are also useful assets. Gemologists work with many different instruments, including a gem microscope, which is more powerful than an average microscope, a refractrometer to measure the refractive index of gems, and a balance beam to measure specific gravity.

2.5 QUANTITATIVE ANALYSIS: CONCENTRATION OF SOLUTIONS

PRACTICE

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Understanding Concepts

1. $v_{\text{ethanol}} = 4.1\text{ L}$

$v_{\text{solution}} = 55\text{ L}$

$c_{\text{solution}} = ?$

$$c_{\text{solution}} = \frac{v_{\text{ethanol}}}{v_{\text{solution}}} \times 100\%$$

$$= \frac{4.1\text{ L}}{55\text{ L}} \times 100\%$$

$$c_{\text{solution}} = 7.5\%\ \text{V/V}$$

The ethanol concentration of a typical gasohol mixture is 7.5% V/V.

2. $m_{ZnCl_2} = 16\text{ g}$

$v_{\text{solution}} = 500\text{ mL}$

$c_{\text{solution}} = ?$

$$c_{\text{solution}} = \frac{m_{ZnCl_2}}{v_{\text{solution}}} \times 100\%$$

$$= \frac{16\text{ g}}{500\text{ mL}} \times 100\%$$

$$c_{\text{solution}} = 3.2\%\ \text{W/V}$$

The concentration of the zinc chloride in solder flux solution is 3.2% W/V.