EXPERIMENT 0

Moles and Chemical Formulas

A. Goal

The goal of this laboratory experiment is to compute the chemical formula of an oxide and to calculate the water percent in a hydrate.

B. Materials

- ☐ rectangular wood piece
- ☐ string
- ☐ ruler
- ☐ 1L graduated cylinder
- ☐ 1qt jar

C. Background

Converting moles into grams and into atoms

A standard way to measure chemicals in the lab is by weight. We can weigh different quantities and the larger the quantity the larger the weight. For a chemical, the weight of a mole is called the molar (or molecular) weight. For example, if we weigh a mole of water (H_2O) we will be weighing 18 grams of water, or if you weigh a mole of table salt (NaCl) the scale will show 58 grams. In this section, you will learn how to calculate the molar mass of a chemical and how to use this property to convert from weight to moles (and moles to weight).

Molar mass of a chemical

Chemicals are made of atoms, and each atom has a specific atomic weight (AW) listed in the periodic table. For example, the atomic weight of Na is 23 grams whereas the atomic weight of Cl is 35 g. The weight of all the atoms of a molecule is called the molecular weight (we call this also molar weight or MW). For example, the molecular weight of NaCl is 58 g, as the weight of Na and Cl is 23 and 35g. Another example would be water, H_2O with a molecular weight of 18g–as the atomic weight of H and O is 1 and 16 g, respectively, and the molecule has two H atoms. The units for molecular weight is $\frac{g}{mol}$, also written as g/mol. To compute the molar mass of a molecule you need to break down the molecule into atoms using the coefficients in the formula. For example, the formula for vinegar is $C_2H_4O_2$ which means a vinegar molecule contains 2C, 4H and 2O atoms. If you add the atomic masses of 2C, 4H, and 2O you will get $60g/mol$. If the chemical formula has a parenthesis, you need to open up the parenthesis to calculate the total number of atoms. As an example, $Ca(NO_3)_2$ contains 1Ca, 2N, and 6O, and its molar mass is $164.09g/mol$.

From moles to grams

The molar mass is used to convert moles to grams or grams to mol. For example, the molar mass of water is $18g/mol$. This means:

$$\boxed{1\text{mole of } H_2O = 18\text{g of } H_2O}$$

that is the same as

$$\boxed{\frac{1 \text{ mole of } H_2O}{18 \text{ grams of } H_2O} \text{ or } \frac{18 \text{ grams of } H_2O}{1 \text{ mole of } H_2O}}$$

From grams to atoms

In the previous sections, we covered how to convert grams to moles, moles to molecules, or molecules to atoms. You can follow the diagram below to switch from one of these properties (atoms, molecules, moles, grams) to another. For example, if you want to convert grams into moles, you will only need one step and you will only have to use a single property: the molar mass. Differently, if you need to convert grams into molecules you will have to use two different steps and use two different properties: the molar mass and Avogadro's number.

Sample Problem 1

Calculate: (a) The atomic weight of Mg; (b) the molecular mass of sulfuric acid, H_2SO_4

SOLUTION

(a) According to the periodic table the atomic weight (AW) of Mg is $24.31 g/mol$. (b) The molar mass of H_2SO_4 is the result of adding the atomic masses of 2H (AW=$1 g/mol$) atoms, 1 S (AW=$32 g/mol$) and 4O (AW=$16 g/mol$) atoms, that gives $98.08 g/mol$.

STUDY CHECK

Calculate the molar mass of glucose $C_6H_{12}O_6$

D. Procedure

1. Empirical formula of an oxyde The goal of this mini experiment is to calculate the formula of an oxide. You will do this by burning up a metal .

Step 1: – Obtain a crucible with a lid, a clay triangle and an iron ring attached to a ring stand. Place the covered crucible in the clay triangle on an iron ring attached to a ring stand. Adjust the height of the ring so that the bottom of the crucible will be in the hottest part of the flame. The correct arrangement of the equipment, crucible, and burner is shown in the figure (Right panel).

Step 2: – Learn how to use the Bunsen burner. Heat the covered crucible in the hottest part of the flame for about 5 min while keeping the lid ajar, making sure that the bottom of the crucible attains a red glow.

Step 3: – Stop the burner and allow the crucible to cool down completely. Weight the covered crucible and record the mass of the covered crucible.

Step 4: – Obtain 0.2 g of magnesium ribbon. Clean the surface of the metal with metallic wool until it shines. Cut the magnesium ribbon into tiny bits, and place them inside the crucible. Cover the crucible, obtain and record the mass again. Now you know the mass of the crucible+lid+Mg.

Step 5: – Set the crucible on the clay triangle with the lid on and heat the crucible in the hottest part of the flame another 5 min. Keep the lid close. Using the crucible tongs, lift the lid carefully by a slight amount. The metal should glow brightly without flames. Continue until all Mg is burned and the product does not glow.

Step 6: – Patiently cool down the crucible with lid. The content should be white or slightly gray. At this point, add a few drops of water using a plastic pipet on the crucible content. You might notice a smell of ammonia at this point.

Step 7: – Place the lid back onto the crucible, slightly ajar, and heat the crucible in the hottest part of the flame for 15 more minutes. After that time, allow the covered crucible and its content to cool down. Obtain the mass of the covered crucible.

Calculations

(1) This is the mass of the empty and clean crucible with lid.

(2) This is the mass of the clean crucible with lid and the Mg.

(3) This is the mass of Mg added to the crucible: (2) − (1)

(4) This is the moles of Mg (Atomic weight 24.305 $g \cdot mol^{-1}$): $n_{Mg} = \frac{(3)\, g}{24.305\ g \cdot mol^{-1}}$

(5) This is the mass of the clean crucible with lid and the product.

(6) This is the mass of product: (5) − (1)

(7) This is the mass of O in the product: (6) − (3)

(8) This is the moles of O (Atomic weight 15.999 $g \cdot mol^{-1}$) in the product: $n_O = \frac{(7)\, g}{15.999\ g \cdot mol^{-1}}$

2. Thermal decomposition of a hydrate The goal of this mini experiment is to calculate the percentage of water contained in an hydrate. You will achieve this goal by heating up the hydrate and measuring its mass before and after heating. The difference in mass will be the mass of water contained in the hydrate.

Step 1: – Place a clean, covered crucible in a clay triangle on an iron ring attached to a ring stand. Adjust the height of the ring so that the bottom of the crucible will be in the hottest part of the flame. The correct arrangement of the equipment, crucible, and burner is shown in the figure (Right panel).

Step 2: – Learn how to use the Bunsen burner. Heat the covered crucible in the hottest part of the flame for about 5 min, making sure that the bottom of the crucible attains a red glow.

Step 3: – Stop the burner and allow the crucible to cool down completely.

Step 4: – Weight the covered crucible and record the mass of the covered crucible.

Step 5: – Weight about 1.5 g of the hydrate.

Step 6: – Add the the hydrate sample onto the crucible and cover the crucible again. Weight the covered crucible with the chemical and record the exact mass in the results sheet.

Step 7: – Heat up the crucible in the hottest part of the flame for about 15 min. The bottom of the crucible should be red hot during this time.

Step 8: – When the crucible is cool, weight and record the mass of the product.

Calculations

(1) Record the mass of the empty crucible with the lid. Remember to weight the crucible in the balance only when completely cool.

(2) Record the mass of the empty crucible with the lid with hydrate.

(3) The mass of hydrate added to the crucible should be:

$$\text{Mass of hydrate} = (2) - (1)$$

(4) After you heat the crucible with hydrate a product will form. Weight the crucible and lid with the final product inside.

(5) You should calculate the mass of product by doing:

$$\text{Mass Product} = (4) - (1)$$

(6) Calculate the mass % of water in the hydrate:

$$\frac{\text{(Mass hydrate)} - \text{(Mass Product)}}{\text{(Mass of hydrate)}} \times 100 = \frac{(3) - (5)}{(3)} \times 100$$

STUDENT INFO

Name: _____ Date: _____

Pre-lab Questions

Moles and Chemical Formulas

---

1. Fill the following conversion to convert 15g of N into moles (AW(N)=14$g \cdot mol^{-1}$)

$$15 \cancel{\text{ g of N}} \times \frac{\qquad \text{moles of N}}{\qquad \cancel{\text{g of N}}} = \qquad \text{moles of N.}$$

2. Fill the following conversion to convert 2 moles of O into moles (AW(O)=16$g \cdot mol^{-1}$)

$$2 \cancel{\text{ moles of O}} \times \frac{\qquad \text{g of O}}{\qquad \cancel{\text{moles of O}}} = \qquad \text{g of O.}$$

3. The thermal decomposition of 5g of an hydrate gives a final product mass of 2.5g. Calculate the percent of water in the hydrate.

4. Name or give the formula of the following compounds:

Magnesium sulfate	_____
$MgSO_4 \cdot H_2O$	_____
Barium chloride	_____
$BaCl_2 \cdot 2\,H_2O$	_____
Chromium(III) chloride	_____
$CoCl_2 \cdot 6\,H_2O$	_____
Nickel(II) sulfate heptahydrate	_____

STUDENT INFO

Name: _____ Date: _____

Results
EXPERIMENT

Moles and Chemical Formulas

---

1. Empirical formula of an oxyde

1	Mass of empty crucible and lid (g)	_____
2	Mass of crucible and lid with Mg (g)	_____
3	Mass of Mg (g)	_____
4	Moles of Mg (mole)	_____
5	Mass of crucible and lid with oxide (g)	_____
6	Mass of oxide(g)	_____
7	Mass of O (g)	_____
8	Moles of O (moles)	_____

	Mg	O
Moles (moles) (8)		
Moles/smallest number (round to closest integer)		
Empirical Formula		

2. Thermal decomposition of a hydrate

Hydrate decomposition Data

(1)	Mass of empty crucible and lid (g)	_____
(2)	Mass of crucible and lid with hydrate (g)	_____
(3)	Mass of hydrate (g)	_____
(4)	Mass of crucible, lid and product (g)	_____
(5)	Mass of product (g)	_____
(6)	Mass % of water	_____

STUDENT INFO

Name: _____ Date: _____

Post-lab Questions

Moles and Chemical Formulas

---

1. Calculate the formula of the oxide resulting of mixing Mg and O according to the respective valences of the elements?

2. Calculate the formula of the nitride resulting of mixing Mg and N according to the respective valences of the elements?

3. The product of burning 5 grams of a hydrate weights 4.5g. Calculate the water % mass of the hydrate.

4. The formula for an hydrate is $FeSO_4 \cdot 7\,H_2O$. Calculate the water % mass of the hydrate.

5. Name the following chemical: $FeSO_4 \cdot 7\,H_2O$.