**Using Mole Ratios**

**Use with Chapter 11,**

**Section 11.2**

Mole ratios relate moles of unknown and known substances in a balanced chemical equation and are used to make stoichiometric mole-to-mole conversions between molar amounts of unknown and known substances.

**C3H8(g)** + **5O2(g)** 0 **3CO2(g)** + **4H2O(g)**

#### To convert

**to use**

|  |
| --- |
| **number of moles of known substance** |
| C H |
| C H |
| C H |
| O |
| O |
| O |
| CO |
| CO |
| CO |
| H O |
| H O |
| H O |

|  |
| --- |
| **number of moles**  **of unknown substance** |
| O |
| CO |
| H O |
| C H |
| CO |
| H O |
| C H |
| O |
| H O |
| C H |
| O |
| CO |

|  |
| --- |
| **mole ratio** |
| **5 mol O2**  **1 mol C3H8** |
| **3 mol CO2**  **1 mol C3H8** |
| **4 mol H2O**  **1 mol C3H8** |
| **1 mol C3H8**  **5 mol O2** |
| **3 mol CO2**  **5 mol O2** |
| **4 mol H2O**  **5 mol O2** |
| **1 mol C3H8**  **3 mol CO2** |
| **5 mol O2**  **3 mol CO2** |
| **4 mol H2O**  **3 mol CO2** |
| **1 mol C3H8**  **4 mol H2O** |
| **5 mol O2**  **4 mol H2O** |
| 1. **mol CO2** 2. **mol H2O** |

**this**

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3 8 2

3 8 2

3 8 2

2 3 8

2 2

2 2

2 3 8

2 2

2 2

2 3 8

2 2

2 2

**Using Mole Ratios**

###### Use with Chapter 11,

**Section 11.2**

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###### For each of the following problems, write the balanced chemical equation that represents the reaction. Then complete the table below by identifying the known substance, the unknown substance, and the mole ratio that you would use to solve each problem correctly.

1. Copper(II) oxide (CuO) decomposes into copper (Cu) and oxygen (O2) gas. What mass of copper will be produced by the decomposition of 1.25 kg CuO?
2. Ammonia (NH3) is produced by the reaction of nitrogen (N2) and hydrogen (H2) gases. How much ammonia will be produced if 22.0 g H2 reacts with excess N2?
3. The reaction of sodium (Na) and water (H2O) produces sodium hydroxide (NaOH) and hydrogen (H2) gas. What mass of hydrogen gas is produced if 17.54 g NaOH is produced by the reaction?
4. The combustion of acetic acid (HC2H3O2) produces carbon dioxide (CO2) and water (H2O). What mass of carbon dioxide will be produced from the combustion of 25.0 g HC2H3O2?
5. 20.0 g of iron(III) sulfide (Fe2S3) was prepared by heating iron (Fe) and excess sulfur (S). What mass of iron was used in the preparation?

|  |  |  |  |
| --- | --- | --- | --- |
| **Problem** | **Chemical Formula of Known Substance** | **Chemical Formula of Unknown Substance** | **Mole Ratio** |
| **1** |  |  |  |
| **2** |  |  |  |
| **3** |  |  |  |
| **4** |  |  |  |
| **5** |  |  |  |

# Solving Stoichiometric Mass-

**to-Mass Conversion Problems**

###### Use with Chapter 11,

**Section 11.2**

unknown substance

What mass in grams of silver (Ag) will be produced when 125 g of silver oxide (Ag2O) decomposes?

**Step 1**

known substance

*Write the balanced equation.*



2Ag2O 0 4Ag + O2

**Step 2**

*Find the number of moles of known substance using mass-to-mole conversion.*

1 mol Ag2O x

2 mol Ag

1 mol Ag2O

1 mol O

107.87 g Ag

x

1 mol Ag

16.00 g O

= 215.74 g Ag

1 mol Ag2O x

x

1. mol Ag2O

1 mol O

= 16.00 g O

Molar mass Ag2O = 231.74 g Ag2O

125 g Ag O x 1 mol Ag2O = 0.539 mol Ag O

2 231.74 g Ag O 2

2

**Step 3**

number of moles of known substance

*Determine the number of moles of the unknown substance from the number of moles of the known substance using mole-to-mole conversions.*

4 mol Ag

2

**Step 4**

0.539 g Ag2O x

1. mol Ag O

= 1.08 mol Ag

number of moles of unknown substance

*Determine the mass of the unknown substance using mole-to-mass conversion.*

107.87 g Ag

1.08 mol Ag x

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1 mol Ag

= 116 g Ag

**Solving Stoichiometric Mass-**

**to-Mass Conversion Problems**

**Use with Chapter 11,**

**Section 11.2**

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1. The reaction of iron(III) oxide (Fe2O3) and hydrogen (H2) is represented by the following unbalanced chemical equation.

Fe2O3(s) + H2(g) 0 Fe(s) + H2O(l) Determine the mass in grams of hydrogen gas needed to react completely with

33.5 g Fe2O3.

**Step 1.**

**Step 2.**

**Step 3.**

**Step 4.**

1. Determine the mass in grams of copper(II) sulfide (Cu2S) formed when 15.0 g copper(I) chloride (CuCl) reacts with excess hydrogen sulfide (H2S) according to the following unbalanced chemical equation.

CuCl(aq) + H2S(g) 0 Cu2S(s) + HCl(aq)

**Step 1.**

**Step 2.**

**Step 3.**

**Step 4.**

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**Determining Mole Ratios**

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**Use with Chapter 11,**

**Section 11.1**

**MATH SKILLS TRANSPARENCY WORKSHEET**

**Using Mole Ratios**

**16**

**Use with Chapter 11,**

**Section 11.2**

**Determine the mole ratios for each of the following balanced chemical equations.**

**1.** 2C(s) + O2(g) 0 2CO(g)

1. **mol O2** /**2 mol C 2 mol CO**/**2 mol C**
2. **mol C**/**1 mol O2 2 mol CO**/**1 mol O2**
3. **mol C**/**2 mol CO 1 mol O2** /**2 mol CO**

**2.** WO3(s) + 3H2(g) 0 W(s) + 3H2O(g)

**For each of the following problems, write the balanced chemical equation that represents the reaction. Then complete the table below by identifying the known substance, the unknown substance, and the mole ratio that you would use to solve each problem correctly.**

* 1. Copper(II) oxide (CuO) decomposes into copper (Cu) and oxygen (O2) gas. What mass of copper will be produced by the decomposition of 1.25 kg CuO?

**2CuO** 0 **2Cu** + **O2**

* 1. Ammonia (NH3) is produced by the reaction of nitrogen (N2) and hydrogen (H2) gases. How much ammonia will be produced if 22.0 g H2 reacts with excess N2?

**N2** + **3H2** 0 **2NH3**

* 1. The reaction of sodium (Na) and water (H2O) produces sodium hydroxide (NaOH) and

1. **mol H**

**2** /**1 mol WO3**

**1 mol W**/**1 mol WO3**

**3 mol H2O**/**1 mol WO3**

hydrogen (H2) gas. What mass of hydrogen gas is produced if 17.54 g NaOH is produced by the reaction?

**1 mol WO3** /**3 mol H2 1 mol W**/**3 mol H2 3 mol H2O**/**3 mol H2**

**1 mol WO3** /**1 mol W 3 mol H2** /**1 mol W 3 mol H2 O**/**1 mol W 1 mol WO3** /**3 mol H2O 3 mol H2** /**3 mol H2 O 1 mol W**/**3 mol H2 O**

1. 2IrCl (aq) + 3NaOH(aq) 0 Ir O (s) + 3HCl(aq) + 3NaCl(aq)

**2Na** + **2H2O** 0 **2NaOH** + **H2**

1. The combustion of acetic acid (HC2H3O2) produces carbon dioxide (CO2) and water (H2O). What mass of carbon dioxide will be produced from the combustion of 25.0 g HC2H3O2?

**HC2H3O2** + **2O2** 0 **2CO2** + **2H2O**

1. 20.0 g of iron(III) sulfide (Fe2S3) was prepared by heating iron (Fe) and excess sulfur (S). What mass of iron was used in the preparation?

3 2 3

**2Fe** + **3S** 0 **Fe2S3**

**3 mol NaOH**/**2 mol IrCl3 1 mol Ir2O3** /**2 mol IrCl3**

**3 mol HCl**/**2 mol IrCl3 3 mol NaCl**/**2 mol IrCl3**

|  |  |  |  |
| --- | --- | --- | --- |
| **Problem** | **Chemical Formula of Known Substance** | **Chemical Formula of Unknown Substance** | **Mole Ratio** |
| **1** | **CuO** | **Cu** | **2 mol Cu**/**2 mol CuO** |
| **2** | **H2** | **NH3** | **2 mol NH3**/**3 mol H2** |
| **3** | **NaOH** | **H2** | **1 mol H2**/**2 mol NaOH** |
| **4** | **HC2H3O2** | **CO2** | **2 mol CO2**/**1 mol HC2H3O2** |
| **5** | **Fe2S3** | **Fe** | **2 mol Fe**/**1 mol Fe2S3** |

**2 mol IrCl3** /**3 mol NaOH 1 mol Ir2O3** /**3 mol NaOH 3 mol HCl**/**3 mol NaOH 3 mol NaCl**/**3 mol NaOH**

**2 mol IrCl3** /**1 mol Ir2O3 3 mol NaOH**/**1 mol Ir2O3 3 mol HCl**/**1 mol Ir2O3 3 mol NaCl**/**1 mol Ir2O3**

**2 mol IrCl3** /**3 mol HCl 3 mol NaOH**/**3 mol HCl 1 mol Ir2O3** /**3 mol HCl 3 mol NaCl**/**3 mol HCl**

**2 mol IrCl3** /**3 mol NaCl 3 mol NaOH**/**3 mol NaCl 1 mol Ir2O3** /**3 mol NaCl 3 mol HCl**/**3 mol NaCl**

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**Solving Stoichiometric Mass- to-Mass Conversion Problems**

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**Use with Chapter 11,**

**Section 11.2**

**MATH SKILLS TRANSPARENCY WORKSHEET**

**Unit Cells of Crystals**

1. Explain what a crystalline solid is.

**18**

**Use with Chapter 12,**

**Section 12.3**

1. The reaction of iron(III) oxide (Fe2O3) and hydrogen (H2) is represented by the following unbalanced chemical equation.

Fe2O3(s) + H2(g) 0 Fe(s) + H2O(l) Determine the mass in grams of hydrogen gas needed to react completely with

33.5 g Fe O .

**A crystalline solid is a solid with an orderly, geometric, three-dimensional structure.**

1. How many surfaces, or faces, do most crystal unit cells have? Which type of unit cell has a different number of faces? What is that number?

**six; hexagonal system; eight**

2 3

**Step 1. Fe2O3** + **3H2** 0 **2Fe** + **3H2O**

**Step 2. 1 mol Fe2O3** x **2 mol Fe**/**1 mol Fe2O3** x **55.85 g Fe**/**1 mol Fe** = **111.7 g Fe 1 mol Fe2O3** x **3 mol O**/**1 mol Fe2O3** x **16.00 g O**/**1 mol O** = **48.00 g O Molar mass Fe2O3** = **159.7 g/mol Fe2O3**

**33.5 g Fe2O3** x **1 mol Fe2O3** /**159.7 g Fe2O3** = **0.210 mol Fe2O3**

**Step 3. 0.210 mol Fe2O3** x **3 mol H2** /**1 mol Fe2O3** = **0.630 g/mol H2**

**Step 4. 1 mol H2** x **2 mol H**/**1 mol H2** x **1.01 g H**/**1 mol H** = **2.02 g H Molar mass H2** = **2.02 g/mol H2**

**0.630 mol H2** x **2.02 g H2** /**1 mol H2** = **1.27 g H2**

1. Determine the mass in grams of copper(II) sulfide (Cu2S) formed when 15.0 g copper(I) chloride (CuCl) reacts with excess hydrogen sulfide (H2S) according to the following unbalanced chemical equation.

CuCl(aq) + H2S(g) 0 Cu2S(s) + HCl(aq)

**Step 1. 2CuCl(aq)** + **H2S** 0 **Cu2S** + **2HCl**

**Step 2. 1 mol CuCl** x **1 mol Cu** /**1 mol CuCl** x **63.55 g Cu**/**1 mol Cu** = **63.55 g Cu 1 mol CuCl** x **1 mol Cl** /**1 mol CuCl** x **35.45 g Cl**/**1 mol Cl** = **35.45 g Cl Molar mass CuCl** = **99.00 g/mol CuCl**

**15.0 g CuCl** x **1 mol CuCl** /**99.00 g CuCl** = **0.152 mol CuCl**

**Step 3. 0.152 mol CuCl** x **1 mol Cu2S**/**2 mol CuCl** = **0.0760 g/mol Cu2S**

**Step 4. 1 mol Cu2S** x **2 mol Cu**/**1 mol Cu2S** x **63.55 g Cu**/**1 mol Cu** = **127.10 g Cu 1 mol Cu2S** x **1 mol S**/**1 mol Cu2S** x **32.07 g S**/**1 mol S** = **32.07 g S**

**Molar mass Cu2S** = **159.17 g/mol Cu2S**

**0.0760 mol Cu2S** x **159.17 g Cu2S**/**1 mol Cu2S** = **12.1 g Cu2S**

1. How many corners do most unit cells have? Which type of unit cell has a different number of corners? What is that number?

**eight; hexagonal system; twelve**

1. What do the letters a, b, and c in the transparency represent?

**The letters represent the edges of the faces of a unit cell.**

1. What do the symbols a., �, and 'Y represent?

**The symbols represent the angles between the faces of a unit cell.**

1. How many dimensions (length, width, depth) are needed to classify a unit cell?

**three**

1. How many faces are needed to determine the dimensions of a unit cell? **two**
2. How many angle measurements are needed to classify a unit cell? **three**
3. Identify the types of unit cells that have three equal dimensions.

**cubic and rhombohedral**

1. Identify the types of unit cells that have equal angles.

**cubic, tetragonal, and orthorhombic**

1. How does the cubic unit cell differ from the rhombohedral unit cell?

**The three equal angles in the cubic unit cell are right angles; in the rhombohedral unit cell, the two equal angles are right angles.**

1. Which unit cells meet the requirements a = b and a . = �?

**cubic, tetragonal, hexagonal, and rhombohedral**

1. How does the triclinic unit cell differ from all the other unit cells?

**In a triclinic unit cell, no angles are equal and no dimensions are equal.**

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