G10 ADV EOT 2 Coverage ppt 2022 - 2023

Chemistry

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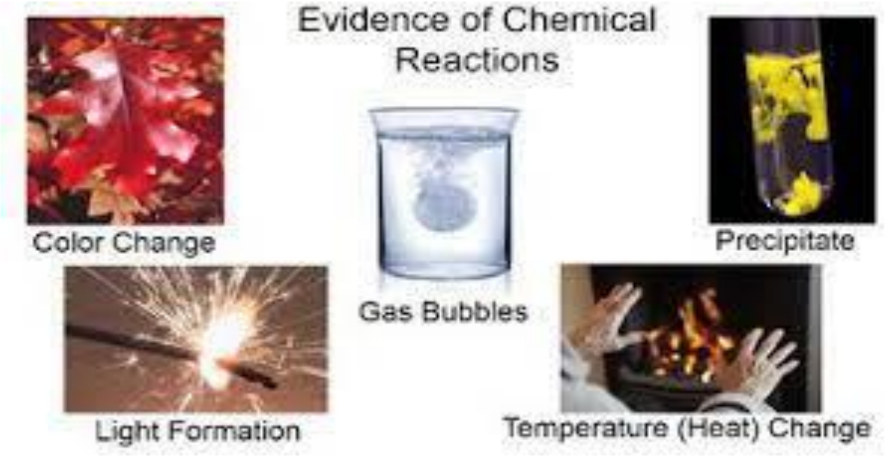
1. Identify the Evidence of chemical change

Evidence of a chemical reaction

- Change in temperature
- Change in color
- Odor, gas, or bubbles may form.



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1. Identify the Evidence of chemical change

Which figures illustrates evidence of a chemical reaction? مثل دليلاً على حدوث تفاعل كيميائي؟

1

2

3

4

Learning Outcomes Covered

- CHM.5.3.01.013
- CHM.5.3.01.014

a. 1 and 3 only 1 و 3 فقط

b. 1 and 2 only 1 و 2 فقط

c. 3 and 4 only 3 و 4 فقط

d. 2 and 3 only 2 و 3 فقط

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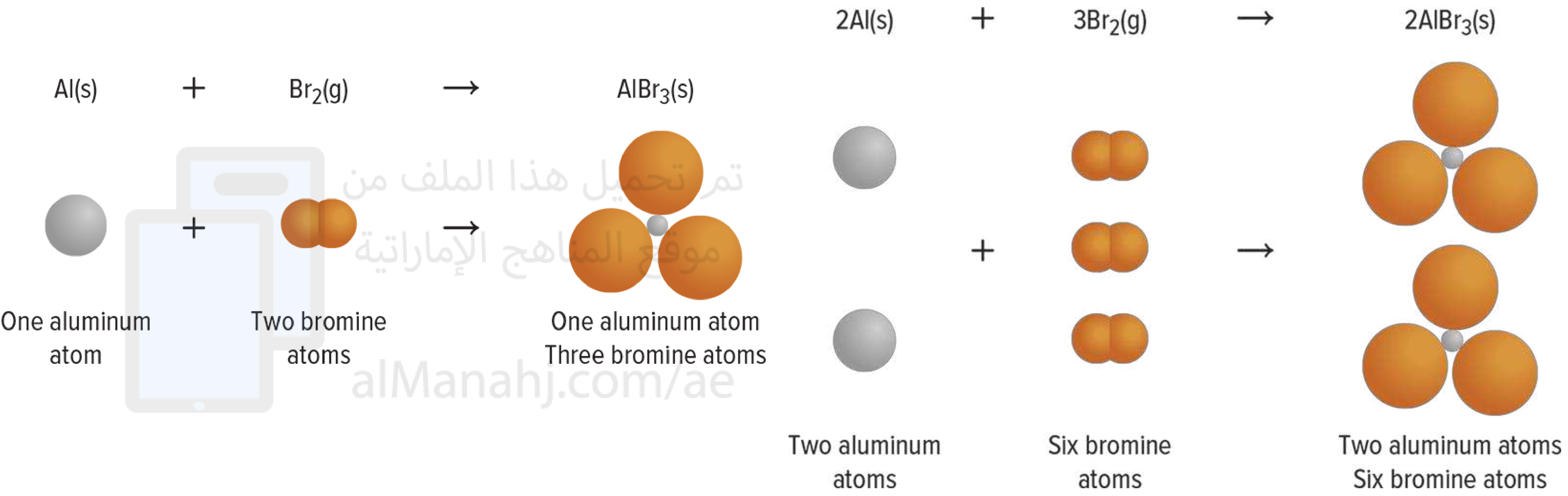
2. Balance chemical equations



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2. Balance chemical equations

Write chemical equations for each of the following reactions.

4. In water, iron (III) chloride reacts with sodium hydroxide, producing solid iron(III) hydroxide and sodium chloride.

5. Liquid carbon disulfide reacts with oxygen gas, producing carbon dioxide gas and sulfur dioxide gas.

6. CHALLENGE A piece of zinc metal is added to a solution of dihydrogen sulfate. This reaction produces a gas and a solution of zinc sulfate.

4. $FeCl_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3NaCl(aq)$
5. $CS_2(l) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$
6. $Zn(s) + H_2SO_4(aq) \rightarrow H_2(g) + ZnSO_4(aq)$

Table 2 Steps for Balancing Equations

Step	Process	Example
1	*Write the skeleton equation for the reaction.* Make sure that the chemical formulas correctly represent the substances. An arrow separates the reactants from the products, and a plus sign separates multiple reactants and products. Show the physical states of all reactants and products.	$H_2(g)$ + $Cl_2(g)$ → $HCl(g)$  Two hydrogen atoms; Two chlorine atoms; One hydrogen atom One chlorine atom
2	*Count the atoms of the elements in the reactants.* If a reaction involves identical polyatomic ions in the reactants and products, count each polyatomic ion as a single element. This reaction does not involve any polyatomic ions. Two atoms of hydrogen and two atoms of chlorine are reacting.	H_2 + Cl_2 → 2 atoms H 2 atoms Cl
3	*Count the atoms of the elements in the products.* One atom of hydrogen and one atom of chlorine are produced.	HCl 1 atom H + 1 atom Cl
4	*Change the coefficients to make the number of atoms of each element equal on both sides of the equation, showing that atoms are conserved.* Never change a subscript in a chemical formula to balance an equation because doing so changes the identity of the substance.	H_2 2 atoms H + Cl_2 2 atoms Cl → 2HCl 2 atoms H + 2 atoms Cl  Two hydrogen atoms; Two chlorine atoms; Two hydrogen atoms Two chlorine atoms
5	*Write the coefficients in their lowest possible ratio.* The coefficients should be the smallest possible whole numbers. The ratio 1 hydrogen to 1 chlorine to 2 hydrogen chloride (1:1:2) is the lowest-possible ratio because the coefficients cannot be reduced further and still remain whole numbers.	$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ 1:1:2 1 H_2 to 1 Cl_2 to 2 HCl
6	*Check your work.* Make sure that the chemical formulas are written correctly. Then, check that the number of atoms of each element is equal on both sides of the equation.	H_2 + Cl_2 → 2HCl 2 atoms H 2 atoms Cl 2 atoms H + 2 atoms Cl There are two hydrogen atoms and two chlorine atoms on both sides of the equation.

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3. Classify of chemical reactions

TABLE 4 PREDICTING PRODUCTS OF CHEMICAL REACTIONS

Type of Reaction	Reactants	Probable Products	Generic Equation
Synthesis	• two or more substances	• one compound	$A + B \rightarrow AB$
Combustion	• a metal and oxygen • a nonmetal and oxygen • a compound and oxygen	• the oxide of the metal • the oxide of the nonmetal • two or more oxides	$A + O_2 \rightarrow AO$
Decomposition	• one compound	• two or more elements and/or compounds	$AB \rightarrow A + B$
Single-replacement	• a metal and a compound • a nonmetal and a compound	• a new compound and the replaced metal • a new compound and the replaced non-metal	$A + BX \rightarrow AX + B$
Double-replacement	• two compounds	• two different compounds, one of which is a solid, water, or a gas	$AX + BY \rightarrow AY + BX$

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3. Classify of chemical reactions

- In a **combustion reaction**, oxygen combines with a substance and releases energy in the form of heat and light.
- Heated hydrogen reacts with oxygen to produce heat and water in a combustion reaction. This is also a synthesis reaction.

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O$$

$$C(s) + O_2(g) \rightarrow CO_2(g)$$

The synthesis reaction between sulfur dioxide and oxygen can also be classified as a **combustion reaction**.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

Figure 8 The light produced by a sparkler is the result of a combustion reaction between oxygen and different metals.

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3. Classify of chemical reactions

What is a reaction of a substance with oxygen and releases energy in the form of heat and light?

ن مادة مع الأكسجين مطلقاً طاقة في صورة

Learning Outcomes Covered

- CHM.5.3.01.016

a. Decomposition reaction تفاعل تفكك

b. Combustion reaction تفاعل احتراق

c. Single Replacement reaction تفاعل استبدال أحادي

d. Double Replacement reaction تفاعل استبدال مزدوج

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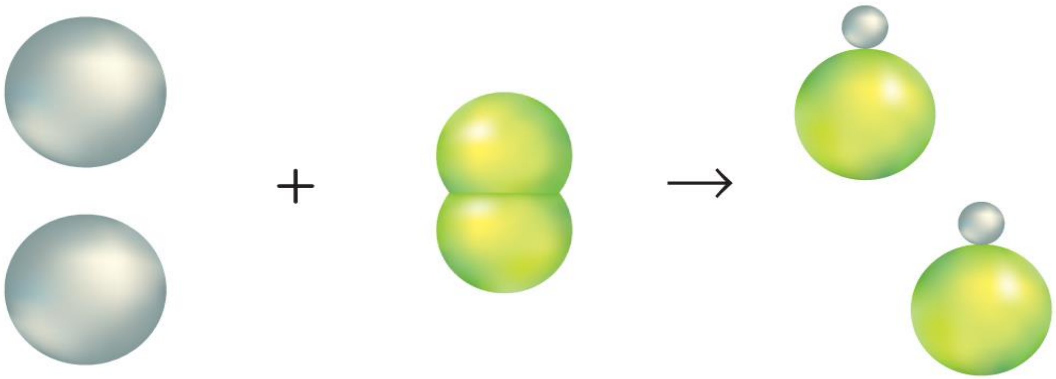
3. Classify of chemical reactions

- A **synthesis reaction** is a reaction in which two or more substances react to produce a single product.
- When two elements react, the reaction is always a synthesis reaction.

$$2Na(s) + Cl_2(g) \longrightarrow 2NaCl(s)$$



Two compounds can also combine to form one compound. For example, the reaction between calcium oxide (CaO) and water (H_2O) to form calcium hydroxide ($Ca(OH)_2$) is a synthesis reaction.

$$CaO\ (s) + H_2O\ (l) \rightarrow Ca(OH)_2\ (s)$$

Another type of synthesis reaction involves a reaction between a compound and an element, as happens when sulfur dioxide gas (SO_2) reacts with oxygen gas (O_2) to form sulfur trioxide (SO_3).

$$2SO_2\ (g) + O_2\ (g) \rightarrow 2SO_3\ (g)$$

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3. Classify of chemical reactions

Which one of the following chemical reaction equations represents a **synthesis reaction**?

التفاعلات الكيميائية التالية تُمثل **تفاعل تكوين**؟

Learning Outcomes Covered

- CHM.5.3.01.016

a. $2KCl_{(s)} + 3O_{2\,(g)} \rightarrow 2\,KClO_{3\,(s)}$

b. $C_5H_{12\,(l)} + 8O_{2\,(g)} \rightarrow 5CO_{2\,(g)} + 6H_2O_{(l)}$

c. $2Pb(NO_3)_{2\,(s)} \rightarrow 2PbO_{(s)} + 4NO_{2\,(g)} + O_{2\,(g)}$

d. $2Al(NO_3)_{3\,(aq)} + 3H_2SO_{4\,(aq)} \rightarrow Al_2(SO_4)_{3\,(aq)} + 6HNO_{3\,(aq)}$

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3. Classify of chemical reactions

Note that the combustion reactions just mentioned are also synthesis reactions. However, not all combustion reactions are synthesis reactions. For example, the reaction involving methane gas (CH_4) and oxygen illustrates a combustion reaction in which one substance replaces another in the formation of products.

$$CH_4\,(g) + 2O_2\,(g) \rightarrow CO_2\,(g) + 2H_2O\,(g)$$

Methane, which belongs to a group of substances called hydrocarbons, is the major component of natural gas. A fireplace that uses natural gas as fuel is shown in **Figure 10.** All hydrocarbons contain carbon and hydrogen and burn in oxygen to yield carbon dioxide and water.

ADDITIONAL PRACTICE

Write chemical equations for the following reactions. Classify each reaction into as many categories as possible.

14. The solids aluminum and sulfur react to produce aluminum sulfide.

15. Water and dinitrogen pentoxide gas react to produce aqueous hydrogen nitrate.

16. The gases nitrogen dioxide and oxygen react to produce dinitrogen pentoxide gas.

17. CHALLENGE Sulfuric acid (H_2SO_4) and sodium hydroxide solutions react to produce aqueous sodium sulfate and water.

14. $2Al(s) + 3S(s) \rightarrow Al_2S_3(s)$; synthesis

15. $H_2O(l) + N_2O_5(g) \rightarrow 2HNO_3(aq)$; synthesis

16. $4NO_2(g) + O_2(g) \rightarrow 2N_2O_5(g)$; synthesis and combustion

17. $H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$; synthesis

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3 & 4. Classify of chemical reactions

EXAMPLE Problem 2

SINGLE-REPLACEMENT REACTIONS

Predict the products that will result when these reactants combine, and write a balanced chemical equation for each reaction.

a. $Fe(s) + CuSO_4(aq) \longrightarrow$

b. $Br_2(l) + MgCl_2(aq) \longrightarrow$

c. $Mg(s) + AlCl_3(aq) \longrightarrow$

a. Iron is listed above copper in the activity series. Therefore, the first reaction will occur because iron is more reactive than copper. In this case, iron will replace copper. The skeleton equation for this reaction is

$$Fe\,(s) + CuSO_4\,(aq) \rightarrow FeS0_4\,(aq) + Cu\,(s)$$

This equation is balanced.

b. In the second reaction, chlorine is more reactive than bromine because bromine is listed below chlorine in the activity series. Therefore, the reaction will not occur. The skeleton equation for this situation is

$$Br\,(l) + MgCl_2\,(aq) \rightarrow NR$$

No balancing is required.

c. Magnesium is listed above aluminum in the activity series. Therefore, the third reaction will occur because magnesium is more reactive than aluminum. In this case, magnesium will replace aluminum. The skeleton equation for this reaction is This equation is not balanced. The balanced equation is

$$Mg\,(s) + AlCl_3\,(aq) \rightarrow Al\,(s) + MgCl_2\,(aq)$$

This equation is not balanced. The balanced equation is $3Mg\,(s) + 2AlCl_3\,(aq) \rightarrow 2Al\,(s) + 3MgCl_2\,(aq)$

Most active ↓ **Least active**

METALS
Lithium
Rubidium
Potassium
Calcium
Sodium
Magnesium
Aluminum
Manganese
Zinc
Iron
Nickel
Tin
Lead
Copper
Silver
Platinum
Gold

Most active ↓ **Least active**

HALOGENS
Fluorine
Chlorine
Bromine
Iodine

Nora

3 & 4. Classify of chemical reactions

ADDITIONAL PRACTICE

Predict whether the following single-replacement reactions will occur. If a reaction occurs, write a balanced equation for the reaction.

21. $K(s) + ZnCl_2(aq) \longrightarrow$

22. $Cl_2(g) + HF(aq) \longrightarrow$

23. $Fe(s) + Na_3PO_4(aq) \longrightarrow$

24. CHALLENGE $Al(s) + Pb(NO_3)_2(aq) \longrightarrow$

21. Yes. K is above Zn in the activity series. $2K(s) + ZnCl_2(aq) \rightarrow Zn(s) + 2KCl(aq)$
22. No. Cl is below F in the activity series.
23. No. Fe is below Na in the activity series.
24. Yes. Al is above Pb in the activity series. $2Al(s) + 3Pb(NO_3)_2(s) \rightarrow 3Pb(s) + 2Al(NO_3)_3(aq)$

Question Predict if the following reactions will occur and indicate products formed.

$Li(s) + NaOH(aq) \rightarrow$

$F_2(g) + HCl(aq) \rightarrow$

$Ag(s) + AlCl_3(aq) \rightarrow$

Answer

$Li(s) + NaOH(aq) \rightarrow Na(s) + LiOH(aq)$

$F_2(g) + 2HCl(aq) \rightarrow Cl_2(g) + 2HF(aq)$

$Ag(s) + AlCl_3(aq) \rightarrow$ no reaction

Most active ↓ **Least active**

METALS
- Lithium
- Rubidium
- Potassium
- Calcium
- Sodium
- Magnesium
- Aluminum
- Manganese
- Zinc
- Iron
- Nickel
- Tin
- Lead
- Copper
- Silver
- Platinum
- Gold

Most active ↓ **Least active**

HALOGENS
- Fluorine
- Chlorine
- Bromine
- Iodine

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3 & 4. Classify of chemical reactions

Using the reactivity series of metals, what would yield the single replacement reaction of calcium (Ca) with zinc nitrate $Zn(NO_3)_2$?

يائي، ما الناتج المتوقع لتفاعل الاستبدال
(مع نترات الخارصين $Zn(NO_3)_2$ ؟

$$Ca_{(s)} + Zn(NO_3)_{2\,(aq)} \rightarrow$$

Learning Outcomes Covered

- CHM.5.3.01.016

a. $CaCl_{2\,(aq)} + Zn_{(s)}$

b. $Zn_{(s)} + Ca(NO_3)_{2\,(aq)}$

c. NR, No Reaction / لن يحدث تفاعل

d. $Zn(NO_3)_{2\,(aq)} + Ca(OH)_{2\,(aq)}$

METALS (Most active → Least active)
Lithium
Rubidium
Potassium
Calcium
Sodium
Magnesium
Aluminum
Manganese
Zinc
Iron
Nickel
Tin
Lead
Copper
Silver
Platinum
Gold

HALOGENS (Most active → Least active)
Fluorine
Chlorine
Bromine
Iodine

3. Classify of chemical reactions

REACTIONS THAT FORM A PRECIPITATE

Write the chemical, complete ionic, and net ionic equations for the reaction between aqueous solutions of barium nitrate and sodium carbonate that forms the precipitate barium carbonate.

$Ba(NO_3)_2\ (aq) + Na_2CO_3\ (aq) \rightarrow BaCO_3\ (s) + NaNO_3\ (aq)$

$Ba(NO_3)_2\ (aq) + Na_2CO_3\ (aq) \rightarrow BaCO_3\ (s) + 2NaNO_3\ (aq)$ Balance the skeleton equation.

$Ba^{2+}\ (aq) + 2NO_3^-\ (aq) + 2Na^+\ (aq) + CO_3^{2-}\ (aq) \rightarrow BaCO_3\ (s) + 2Na^+\ (aq) + 2NO_3^-\ (aq)$ Show the ions of the reactants and the products.

$Ba^{2+}\ (aq) + \cancel{2NO_3^-\ (aq)} + \cancel{2Na^+\ (aq)} + CO_3^{2-}\ (aq) \rightarrow BaCO_3\ (s) + \cancel{2Na^+\ (aq)} + \cancel{2NO_3^-\ (aq)}$ Cross out the spectator ions from the complete ionic equation.

$Ba^2 + (aq) + CO_3^{2-}\ (aq) \rightarrow BaCO_3\ (s)$ Write the net ionic equation.

ADDITIONAL PRACTICE

Write chemical, complete ionic, and net ionic equations for each of the following reactions that might produce a precipitate. Use *NR* to indicate that no reaction occurs.

35. Aqueous solutions of potassium iodide and silver nitrate are mixed, forming the precipitate silver iodide.

36. Aqueous solutions of ammonium phosphate and sodium sulfate are mixed. No precipitate forms and no gas is produced.

37. Aqueous solutions of aluminum chloride and sodium hydroxide are mixed, forming the precipitate aluminum hydroxide.

38. Aqueous solutions of lithium sulfate and calcium nitrate are mixed, forming the precipitate calcium sulfate.

39. CHALLENGE When aqueous solutions of sodium carbonate and manganese(V) chloride are mixed, a precipitate forms. The precipitate is a compound containing manganese.

35. chemical equation: $KI(aq) + AgNO_3(aq) \rightarrow KNO_3(aq) + AgI(s)$; complete ionic equation: $\cancel{K^+(aq)} + I^-(aq) + Ag^+(aq) + \cancel{NO_3^-(aq)} \rightarrow \cancel{K^+(aq)} + \cancel{NO_3^-(aq)} + AgI(s)$; net ionic equation: $I^-(aq) + Ag^+(aq) \rightarrow AgI(s)$

36. chemical equation: $2(NH_4)_3PO_4(aq) + 3Na_2SO_4(aq) \rightarrow 3(NH_4)_2SO_4(aq) + 2Na_3PO_4(aq)$;
complete ionic equation: $\cancel{6NH_4^+(aq)} + \cancel{2PO_4^{3-}(aq)} + \cancel{6Na^+(aq)} + \cancel{3SO_4^{2-}(aq)} \rightarrow \cancel{6NH_4^+(aq)} + \cancel{3SO_4^{2-}(aq)} + \cancel{6Na^+(aq)} + \cancel{2PO_4^{3-}(aq)}$
No reaction occurs; therefore, there is no net ionic equation.

37. chemical equation: $AlCl_3(aq) + 3NaOH(aq) \rightarrow Al(OH)_3(s) + 3NaCl(aq)$; complete ionic equation: $Al^{3+}(aq) + \cancel{3Cl^-(aq)} + \cancel{3Na^+(aq)} + 3OH^-(aq) \rightarrow Al(OH)_3(s) + \cancel{3Na^+(aq)} + \cancel{3Cl^-(aq)}$ net ionic equation: $Al^{3+}(aq) + 3OH^-(aq) \rightarrow Al(OH)_3(s)$

38. chemical equation: $Li_2SO_4(aq) + Ca(NO_3)_2(aq) \rightarrow 2LiNO_3(aq) + CaSO_4(s)$; complete ionic equation: $\cancel{2Li^+(aq)} + SO_4^{2-}(aq) + Ca^{2+}(aq) + \cancel{2NO_3^-(aq)} \rightarrow \cancel{2Li^+(aq)} + \cancel{2NO_3^-(aq)} + CaSO_4(s)$; net ionic equation: $SO_4^{2-}(aq) + Ca^{2+}(aq) \rightarrow CaSO_4(s)$

39. chemical equation: $5Na_2CO_3(aq) + 2MnCl_5(aq) \rightarrow 10NaCl(aq) + Mn_2(CO_3)_5(s)$; complete ionic equation: $\cancel{10Na^+(aq)} + 5CO_3^{2-}(aq) + 2Mn^{5+}(aq) + \cancel{10Cl^-(aq)} \rightarrow \cancel{10Na^+(aq)} + \cancel{10Cl^-(aq)} + Mn_2(CO_3)_5(s)$;
net ionic equation: $5CO_3^{2-}(aq) + 2Mn^{5+}(aq) \rightarrow Mn_2(CO_3)_5(s)$

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3. Classify of chemical reactions

REACTIONS THAT FORM WATER

Write the chemical, complete ionic, and net ionic equations for the reaction between hydrochloric acid and aqueous lithium hydroxide. This reaction produces water and aqueous lithium chloride.

$HCl\,(aq) + LiOH\,(aq) \rightarrow H_2O\,(l) + LiCl\,(aq)$

$H^+\,(aq) + Cl^-\,(aq) + Li^+\,(aq) + OH^-\,(aq) \rightarrow H_2O\,(l) + Li^+\,(aq) + Cl^-\,(aq)$ — Show the ions of the reactants and the products.

$H^+\,(aq) + \cancel{Cl^-\,(aq)} + \cancel{Li^+\,(aq)} + OH^-\,(aq) \rightarrow H_2O\,(l) + \cancel{Li^+\,(aq)} + \cancel{Cl^-\,(aq)}$ — Cross out the spectator ions from the complete ionic equation.

$H^+\,(aq) + OH^-\,(aq) \rightarrow H_2O\,(l)$ — Write the net ionic equation.

Write chemical, complete ionic, and net ionic equations for the reactions between the following substances, which produce water.

40. Mixing sulfuric acid (H_2SO_4) and aqueous potassium hydroxide produces water and aqueous potassium sulfate.

41. Mixing hydrochloric acid (HCl) and aqueous calcium hydroxide produces water and aqueous calcium chloride.

42. Mixing nitric acid (HNO_3) and aqueous ammonium hydroxide produces water and aqueous ammonium nitrate.

43. Mixing hydrosulfuric acid (H_2S) and aqueous calcium hydroxide produces water and aqueous calcium sulfide.

44. CHALLENGE When benzoic acid (C_6H_5COOH) and magnesium hydroxide are mixed, water and magnesium benzoate are produced.

40. chemical equation: $H_2SO_4(aq) + 2KOH(aq) \rightarrow 2H_2O(l) + K_2SO_4(aq)$; complete ionic equation: $2H^+(aq) + \cancel{SO_4^{2-}(aq)} + \cancel{2K^+(aq)} + 2OH^-(aq) \rightarrow 2H_2O(l) + \cancel{2K^+(aq)} + \cancel{SO_4^{2-}(aq)}$; net ionic equation: $2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(l)$, simplified to $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

41. chemical equation: $2HCl(aq) + Ca(OH)_2(aq) \rightarrow 2H_2O(l) + CaCl_2(aq)$; complete ionic equation: $2H^+(aq) + \cancel{2Cl^-(aq)} + \cancel{Ca^{2+}(aq)} + 2OH^-(aq) \rightarrow 2H_2O(l) + \cancel{Ca^{2+}(aq)} + \cancel{2Cl^-(aq)}$ net ionic equation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

42. chemical equation: $HNO_3(aq) + NH_4OH(aq) \rightarrow H_2O(l) + NH_4NO_3(aq)$ complete ionic equation: $H^+(aq) + \cancel{NO_3^-(aq)} + \cancel{NH_4^+(aq)} + OH^-(aq) \rightarrow H_2O(l) + \cancel{NH_4^+(aq)} + \cancel{NO_3^-(aq)}$; net ionic equation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

43. chemical equation: $H_2S(aq) + Ca(OH)_2(aq) \rightarrow 2H_2O(l) + CaS(aq)$; complete ionic equation: $2H^+(aq) + \cancel{S^{2-}(aq)} + \cancel{Ca^{2+}(aq)} + 2OH^-(aq) \rightarrow 2H_2O(l) + \cancel{Ca^{2+}(aq)} + \cancel{S^{2-}(aq)}$; net ionic equation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

44. chemical equation: $2C_6H_5COOH(aq) + Mg(OH)_2(aq) \rightarrow Mg(C_6H_5COO)_2(aq) + 2H_2O(l)$; complete ionic equation: $\cancel{2C_6H_5COO^-(aq)} + 2H^+(aq) + \cancel{Mg^{2+}(aq)} + 2OH^-(aq) \rightarrow \cancel{2C_6H_5COO^-(aq)} + \cancel{Mg^{2+}(aq)} + 2H_2O(l)$; net ionic equation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

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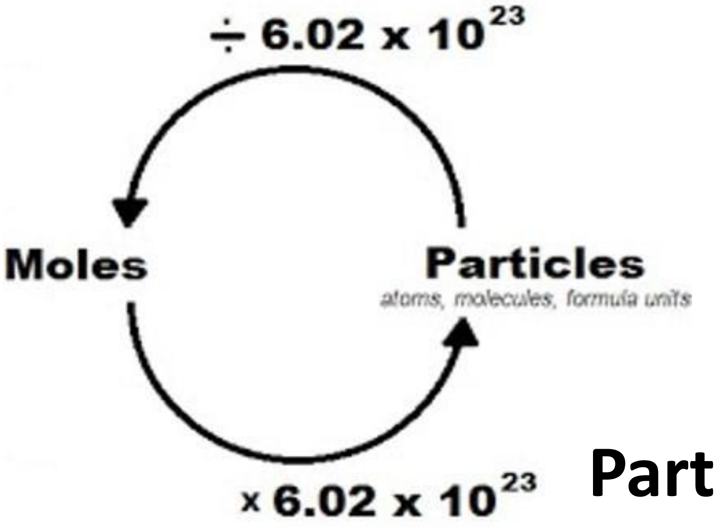
7 & 8. Convert of moles to number of representative particles and vice versa

1 mole is the number of atoms in 12 g of pure carbon-12, or 6.02 × 10^{23} representative particles



Moles to Particles

- Use Avogadro's number as a conversion factor.
- Number of molecules in 3.50 mol of sucrose:

$$3.50\ \text{mol sucrose} \times \frac{6.02 \times 10^{23}\ \text{molecules}}{1\ \text{mol sucrose}} = 2.11 \times 10^{24}\ \text{molecules}$$

Particles to Moles

- Use the inverse of Avogadro's number as a conversion factor.

$$\text{Number of representative particles} \times \frac{1\ \text{mol}}{6.02 \times 10^{23}\ \text{particles}}$$

- Express 2.11 × 10^{24} molecules of sucrose in moles:

$$2.11 \times 10^{24}\ \text{molecules sucrose} \times \frac{1\ \text{mol sucrose}}{6.02 \times 10^{23}\ \text{molecules}} = 3.50\ \text{mol sucrose}$$

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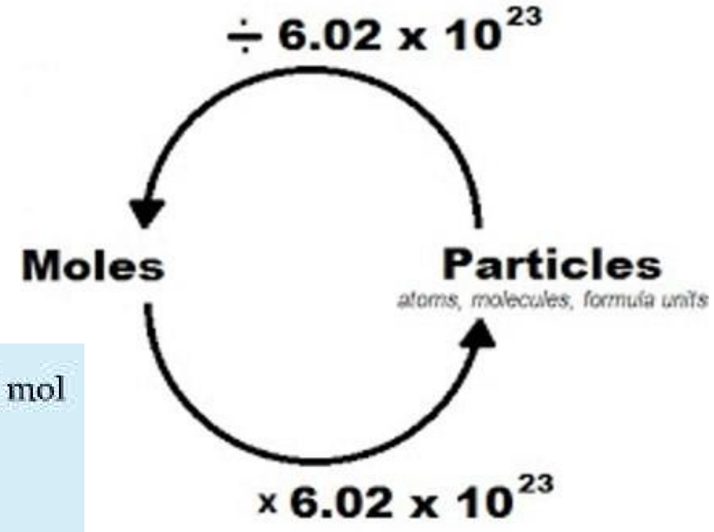
7 & 8. Convert of moles to number of representative particles and vice versa



1. Zinc (Zn) is used to form a corrosion-inhibiting surface on galvanized steel. Determine the number of Zn atoms in 2.50 mol of Zn.

2. Calculate the number of molecules in 11.5 mol of water (H_2O).

3. Silver nitrate ($AgNO_3$) is used to make several different silver halides used in photographic films. How many formula units of $AgNO_3$ are there in 3.25 mol of $AgNO_3$?

4. **CHALLENGE** Calculate the number of oxygen atoms in 5.00 mol of oxygen molecules. Oxygen is a diatomic molecule, O_2.

1. 1.51×10^{24} atoms

2. 6.92×10^{24} molecules
3. 1.96×10^{24} formula units
4. 6.02×10^{24} atoms

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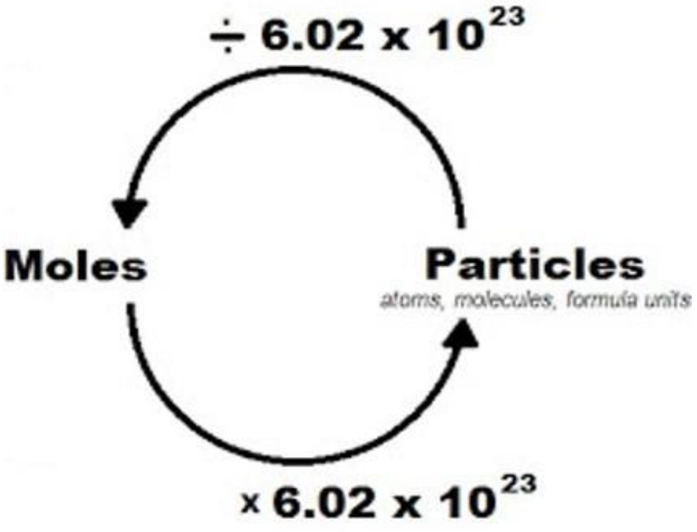
7 & 8. Convert of moles to number of representative particles and vice versa



5. How many moles contain each of the following?

a. 5.75×10^{24} atoms Al

b. 2.50×10^{20} atoms Fe

6. CHALLENGE Identify the representative particle for each formula, and convert the given number of representative particles to moles.

a. 3.75×10^{24} CO_2

b. 3.58×10^{23} $ZnCl_2$

5. a. 9.55 mol
   b. 4.15×10^{-4} mol
6. a. a molecule; 6.23 mol CO_2
   b. a formula unit; 0.595 mol $ZnCl_2$

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7 & 8. Convert of moles to number of representative particles and vice versa

How many molecules are in 60.0 g of glucose ($C_6H_{12}O_6$)?

Molar mass of glucose ($C_6H_{12}O_6$) = 180 g/mol
Avogadro's number = 6.02×10^{23}

Learning Outcomes Covered

- CHM.5.3.01.003
- CHM.5.3.01.004

a. 7.83×10^{22}

b. 9.22×10^{22}

c. 2.01×10^{23}

d. 5.16×10^{23}

What is the number of atoms in a 0.645 mol sample of argon gas (Ar)?

، الموجودة في 0.645 mol من عينة من
؟(Ar)

Avogadro's number = 6.02×10^{23}

6.02×10^{23}

Learning Outcomes Covered

- CHM.5.3.01.003

a. 3.88×10^{23} atom — ذرة 3.88×10^{23}

b. 4.62×10^{23} atom — ذرة 4.62×10^{23}

c. 1.07×10^{23} atom — ذرة 1.07×10^{23}

d. 9.33×10^{23} atom — ذرة 9.33×10^{23}

Nora

7 & 8. Convert of moles to number of representative particles and vice versa

How many moles contained in 2.50×10^{24} molecules of ammonia NH_3? في 2.50×10^{24} جزيء

Avogadro's number = 6.02×10^{23} 6.(

Learning Outcomes Covered

- CHM.5.3.01.004

a. 0.42 mol

b. 4.15 mol

c. 0.24 mol

d. 2.40 mol

Which of the following does **NOT** describe the mole?

Learning Outcomes Covered

- CHM.5.3.01.003

a. A unit used to count particles directly

b. Avogadro's number of molecules of a compound

c. The number of atoms in exactly 12 g of pure C-12 1 جرام

d. The SI base unit used to measure the amount of a substance SI التي

Nora

9, 10 & 12. Convert the number of moles to the mass of a compound and vice versa

Moles to Mass

- Suppose you need 3.00 mol of copper for a chemical reaction

$$\text{number of moles} \times \frac{\text{mass in grams}}{1 \text{ mole}} = \text{mass}$$

$$3.00 \text{ mol Cu} \times \frac{63.546 \text{ g Cu}}{1 \text{ mol Cu}} = 191 \text{ g Cu}$$

- 3.00 mol of copper has a mass of 191 g.

15. Determine the mass in grams of each of the following.

a. 3.57 mol Al

b. 4.26 mol Si

16. CHALLENGE Convert each given quantity in scientific notation to mass in grams expressed in scientific notation.

a. 3.45×10^2 mol Co

b. 2.45×10^{-2} mol Zn

15. a. 96.3 g Al
    b. 1.20×10^3 g Si

16. a. 2.03×10^4 g Co
    b. 1.60 g Zn

17. Determine the number of moles in each of the following.

a. 25.5 g Ag

b. 300.0 g S

18. CHALLENGE Convert each mass to moles. Express the answer in scientific notation.

a. 1.25×10^3 g Zn

b. 1.00 kg Fe

17. a. 0.236 mol Ag
    b. 9.355 mol S

18. a. 1.91×10^1 mol Zn
    b. 1.79×10^1 mol Fe

Nora

9, 10 & 12. Convert the number of moles to the mass of a compound and vice versa

EXAMPLE Problem 2

MOLE-TO-MASS CONVERSION Chromium (Cu), a transition element, is a component of chrome plating. Chrome plating used on metals and in steel alloys to control corrosion. Calculate the mass in grams of 0.0450 mol Cr.

1. ANALYZE THE PROBLEM

You are given the number of moles of chromium and must convert it to an equivalent mass using the molar mass of chromium from the periodic table. Because the sample is less than one-tenth of a mole, the answer should be less than one-tenth of the molar mass.

Known	Unknown
number of moles = 0.0450 mol Cr	mass Cr = ? g
molar mass Cr = 52.00 g/mol Cr	

2. SOLVE FOR THE UNKNOWN

Use a conversion factor—the molar mass—that relates grams of chromium to moles of chromium. Write the conversion factor with moles of chromium in the denominator and grams of chromium in the numerator. Substitute the known values into the equation and solve.

$$\text{moles Cr} \times \frac{\text{grams Cr}}{1\ \text{mol Cr}} = \textbf{grams Cr}$$

Apply the conversion factor.

$$0.0450\ \cancel{\text{mol Cr}} \times \frac{52.00\ \text{g Cr}}{1\ \cancel{\text{mol Cr}}} = \textbf{2.34 g Cr}$$

Substitute 0.0450 mol for moles Cr and 52.00 g/mol for molar mass of Cr. Multiply and divide numbers and units.

Nora

9, 10 & 12. Convert the number of moles to the mass of a compound and vice versa

EXAMPLE Problem 3

MASS-TO-MOLE CONVERSION Calcium (Ca), the fifth most-abundant element on Earth, is always found combined with other elements because of its high reactivity. How many moles of calcium are in 525 g Ca?

1. ANALYZE THE PROBLEM

You must convert the mass of calcium to moles of calcium. The mass of calcium is more than ten times larger than the molar mass. Therefore, the answer should be greater than 10 mol.

Known	Unknown
mass = 525 g Ca	number of moles Ca = ? mol
molar mass Ca = 40.08 g/mol Ca	

2. SOLVE FOR THE UNKNOWN

Use a conversion factor—the inverse of molar mass—that relates moles of calcium to grams of calcium. Substitute the known values and solve.

$$\text{mass Ca} \times \frac{1 \text{ mol Ca}}{\text{grams Ca}} = \textbf{moles Ca}$$

Apply the conversion factor.

$$525 \ \cancel{\text{g Ca}} \times \frac{1 \text{ mol Ca}}{40.08 \ \cancel{\text{g Ca}}} = \textbf{13.1 mol Ca}$$

Substitute mass Ca = 525 g, and inverse molar mass of Ca = 1 mol/40.08 g. Multiply and divide numbers and units.

Nora

9, 10 & 12. Convert the number of moles to the mass of a compound and vice versa

Use with Example Problem 7.

Problem

The characteristic odor of garlic is due to allyl sulfide $[(C_3H_5)_2S]$. What is the mass of 2.50 mol of $(C_3H_5)_2S$?

SOLVE FOR THE UNKNOWN

Calculate the molar mass of $(C_3H_5)_2S$.

- Multiply the moles of S in the compound by the molar mass of S.

$$1\ \cancel{\text{mol S}} \times \frac{32.07\ \text{g S}}{1\ \cancel{\text{mol S}}} = 32.07\ \text{g S}$$

- Multiply the moles of C in the compound by the molar mass of C.

$$6\ \cancel{\text{mol C}} \times \frac{12.01\ \text{g C}}{1\ \cancel{\text{mol C}}} = 72.06\ \text{g C}$$

- Multiply the moles of H in the compound by the molar mass of H.

$$10\ \cancel{\text{mol H}} \times \frac{1.008\ \text{g H}}{1\ \cancel{\text{mol H}}} = 10.08\ \text{g H}$$

SOLVE FOR THE UNKNOWN

- Total the mass values.

molar mass = (32.07 g + 72.06 g + 10.08 g) = **114.21 g/mol $(C_3H_5)_2S$**

Use a conversion factor—the molar mass—that relates grams to moles.

- Apply the conversion factor.

$$\text{moles } (C_3H_5)_2S \times \frac{\text{grams}(C_3H_5)_2S}{1\ \text{mol}(C_3H_5)_2S} = \mathbf{mass(C_3H_5)_2S}$$

- Substitute moles $(C_3H_5)_2S$ = 2.5 mol, molar mass $(C_3H_5)_2S$ = 114.21 g/mol, and solve.

$$2.50\ \cancel{\text{mol } (C_3H_5)_2S} \times \frac{114.21\ \text{g } (C_3H_5)_2S}{1\ \cancel{\text{mol } (C_3H_5)_2S}} = \mathbf{286\ g\ (C_3H_5)_2S}$$

Nora

9, 10 & 12. Convert the number of moles to the mass of a compound and vice versa

34. Determine the molar mass of each ionic compound.

a. NaOH

b. $CaCl_2$

c. $KC_2H_3O_2$

35. Calculate the molar mass of each molecular compound.

a. C_2H_5OH

b. HCN

c. CCl_4

36. CHALLENGE Identify each substance as a molecular compound or an ionic compound, and then calculate its molar mass.

a. $Sr(NO_3)_2$

b. $(NH_4)_3PO_4$

c. $C_{12}H_{22}O_{11}$

34. a. 40.00 g/mol
    b. 110.98 g/mol
    c. 98.14 g/mol

35. a. 46.07 g/mol
    b. 27.03 g/mol
    c. 153.81 g/mol

36. a. ionic; 211.64 g/mol
    b. ionic; 149.10 g/mol
    c. molecular; 342.30 g/mol

Nora

9, 10 & 12. Convert the number of moles to the mass of a compound and vice versa

37. The United States chemical industry produces more sulfuric acid (H_2SO_4), in terms of mass, than any other chemical. What is the mass of $3.25\ \text{mol}$ of H_2SO_4?

38. What is the mass of $4.35 \times 10^{-2}\ \text{mol}$ of zinc chloride ($ZnCl_2$)?

39. CHALLENGE Write the chemical formula for potassium permanganate, and then calculate the mass in grams of $2.55\ \text{mol}$ of the compound.

37. 319 g
38. 5.93 g
39. $KMnO_4$; 403 g

Nora

9, 10 & 12. Convert the number of moles to the mass of a compound and vice versa

What is the molar mass for the compound C_2H_5OH ?

HYDROGEN 1 **H** 1.00	**Periodic Table Elements 1– 18**				
LITHIUM 3	BERYLLIUM 4	BORON 5	CARBON 6	NITROGEN 7	OXYGE 8

Learning Outcomes Covered

- CHM.5.3.01.004

a. 34.0 g/mol

b. 46.0 g/mol

c. 62.0 g/mol

d. 89.0 g/mol

How many moles of carbon dioxide CO_2 will be produced if 100.0 g of potassium hydrogen carbonate $KHCO_3$ have decomposed?

$2KHCO_{3\,(s)} \rightarrow K_2CO_{3\,(s)} + CO_{2\,(g)} +$

(Molar Mass of $KHCO_3$ = 100 g/mol)

Learning Outcomes Covered

- CHM.5.3.01.013

a. 1 mol

b. 2 mol

c. 0.5 mol

d. 0.25 mol

Nora

9, 10 & 12. Convert the number of moles to the mass of a compound and vice versa

How many moles are in 22.0 g of CO_2?

Molar mass CO_2 = 44 g/mol

Learning Outcomes Covered

- CHM.5.3.01.004

a. 0.50 mol

b. 0.60 mol

c. 1.25 mol

d. 2.00 mol

Which of the following statements are correct related to mass and the mole?

لكتلة والمول؟

1	A mole always contains the same number of particles	الجسيمات
2	Moles of different substances have different masses	تلفة
3	Converting from mass to mole we use a fixed ratio for all elements	نسبة واحدة وثابتة لكل العناصر

Learning Outcomes Covered

- CHM.5.3.01.003
- CHM.5.3.01.013
- CHM.5.3.01.014

a. 2 and 3 — 2 و 3

b. 1 and 3 — 1 و 3

c. 1 and 2 — 1 و 2

d. 1 ,2 and 3 — 1 و 2 و 3

Nora

6. Predict whether reactions in aqueous solutions will produce gas

REACTIONS THAT FORM GASES

Write the chemical, complete ionic, and net ionic equations for the reaction between hydrochloric acid and aqueous sodium sulfide, which produces hydrogen sulfide gas.

$HCl(aq) + Na_2S(aq) \rightarrow H_2S(g) + NaCl(aq)$

$2HCl(aq) + Na_2S(aq) \rightarrow H_2S(g) + 2NaCl(aq)$ — Balance the skeleton equation.

$2H^+(aq) + 2Cl^-(aq) + 2Na^+(aq) + S^{2-}(aq) \rightarrow H_2S(g) + 2Na^+(aq) + 2Cl^-(aq)$ — Show the ions of the reactants and the products.

$2H^+(aq) + \cancel{2Cl^-(aq)} + \cancel{2Na^+(aq)} + S^{2-}(aq) \rightarrow H_2S(g) + \cancel{2Na^+(aq)} + 2Cl^-(aq)$ — Cross out the spectator ions from the complete ionic equation.

$2H^+(aq) + S^{2-}(aq) \rightarrow H_2S(g)$ — Write the net ionic equation in its smallest whole-number ratio.

ADDITIONAL PRACTICE

Write chemical, complete ionic, and net ionic equations for these reactions.

45. Perchloric acid ($HClO_4$) reacts with aqueous potassium carbonate, forming carbon dioxide gas and water.

46. Sulfuric acid (H_2SO_4) reacts with aqueous sodium cyanide, forming hydrogen cyanide gas and aqueous sodium sulfate.

47. Hydrobromic acid (HBr) reacts with aqueous ammonium carbonate, forming carbon dioxide gas and water.

48. Nitric acid (HNO_3) reacts with aqueous potassium rubidium sulfide, forming hydrogen sulfide gas.

49. CHALLENGE Aqueous potassium iodide reacts with lead nitrate in solution, forming solid lead iodide.

45. chemical equation: $2HClO_4(aq) + K_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g) + 2KClO_4(aq)$; complete ionic equation: $2H^+(aq) + \cancel{2ClO_4^-(aq)} + \cancel{2K^+(aq)} + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g) + \cancel{2K^+(aq)} + \cancel{2ClO_4^-(aq)}$; net ionic equation: $2H^+(aq) + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g)$

46. chemical equation: $H_2SO_4(aq) + 2NaCN(aq) \rightarrow 2HCN(g) + Na_2SO_4(aq)$; complete ionic equation: $2H^+(aq) + \cancel{SO_4^{2-}(aq)} + \cancel{2Na^+(aq)} + 2CN^-(aq) \rightarrow 2HCN(g) + \cancel{2Na^+(aq)} + \cancel{SO_4^{2-}(aq)}$; net ionic equation: $2H^+(aq) + 2CN^-(aq) \rightarrow 2HCN(g)$, simplified to $H^+(aq) + CN^-(aq) \rightarrow HCN(g)$

47. chemical equation: $2HBr(aq) + (NH_4)_2CO_3(aq) \rightarrow H_2O(l) + CO_2(g) + 2NH_4Br(aq)$; complete ionic equation: $2H^+(aq) + \cancel{2Br^-(aq)} + \cancel{2NH_4^+(aq)} + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g) + \cancel{2NH_4^+(aq)} + \cancel{2Br^-(aq)}$; net ionic equation: $2H^+(aq) + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g)$

48. chemical equation: $2HNO_3(aq) + KRbS(aq) \rightarrow H_2S(g) + KRb(NO_3)_2(aq)$; complete ionic equation: $2H^+(aq) + \cancel{2NO_3^-(aq)} + \cancel{K^+(aq)} + \cancel{Rb^+(aq)} + S^{2-}(aq) \rightarrow H_2S(g) + \cancel{K^+(aq)} + \cancel{Rb^+(aq)} + \cancel{2NO_3^-(aq)}$; net ionic equation: $2H^+(aq) + S^{2-}(aq) \rightarrow H_2S(g)$

49. chemical equation: $2KI(aq) + Pb(NO_3)_2(aq) \rightarrow 2KNO_3(aq) + PbI_2(s)$; complete ionic equation: $\cancel{2K^+(aq)} + 2I^-(aq) + Pb^{2+}(aq) + \cancel{2NO_3^-(aq)} \rightarrow \cancel{2K^+(aq)} + \cancel{2NO_3^-(aq)} + PbI_2(s)$ net ionic equation: $Pb^{2+}(aq) + 2I^-(aq) \rightarrow PbI_2(s)$

Nora

6. Predict whether reactions in aqueous solutions will produce gas

Which one of the following reactions in aqueous solution produce gases? ناعلات التي

Learning Outcomes Covered

- CHM.5.3.03.006

a. $2HI_{(aq)} + Li_2S_{(aq)} \rightarrow H_2S_{(g)} + 2LiI_{(aq)}$

b. $2NaOH_{(aq)} + CuCl_{2(aq)} \rightarrow 2NaCl_{(aq)} + Cu(OH)_{2(s)}$

c. $CaO_{(s)} + CO_{2(g)} \rightarrow CaCO_{3(s)}$

d. $2HClO_{(aq)} + Ca(OH)_{2(aq)} \rightarrow 2H_2O_{(l)} + Ca(ClO)_{2(aq)}$

What is the meaning of spectator ions? نات المقترحة؟

Learning Outcomes Covered

- CHM.5.3.01.020

a. The total ions in the solution of a reaction لموجو في محلول التفاعل

b. Ions that do not participate in a reaction تشارك في التفاعل

c. Ions that produce solid precipitate from the reaction للمادة الصلبة الراسبة من التفاعل

d. Ions that produce gas released from the reaction للغاز المتصاعد من التفاعل

6. Predict whether reactions in aqueous solutions will produce water

REACTIONS THAT FORM WATER

Write the chemical, complete ionic, and net ionic equations for the reaction between hydrochloric acid and aqueous lithium hydroxide. This reaction produces water and aqueous lithium chloride.

$HCl(aq) + LiOH(aq) \rightarrow H_2O(l) + LiCl(aq)$

$H^+(aq) + Cl^-(aq) + Li^+(aq) + OH^-(aq) \rightarrow H_2O(l) + Li^+(aq) + Cl^-(aq)$ Show the ions of the reactants and the products.

$H^+(aq) + \cancel{Cl^-(aq)} + \cancel{Li^+(aq)} + OH^-(aq) \rightarrow H_2O(l) + \cancel{Li^+(aq)} + \cancel{Cl^-(aq)}$ Cross out the spectator ions from the complete ionic equation.

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ Write the net ionic equation.

Write chemical, complete ionic, and net ionic equations for the reactions between the following substances, which produce water.

40. Mixing sulfuric acid (H_2SO_4) and aqueous potassium hydroxide produces water and aqueous potassium sulfate.

41. Mixing hydrochloric acid (HCl) and aqueous calcium hydroxide produces water and aqueous calcium chloride.

42. Mixing nitric acid (HNO_3) and aqueous ammonium hydroxide produces water and aqueous ammonium nitrate.

43. Mixing hydrosulfuric acid (H_2S) and aqueous calcium hydroxide produces water and aqueous calcium sulfide.

44. CHALLENGE When benzoic acid (C_6H_5COOH) and magnesium hydroxide are mixed, water and magnesium benzoate are produced.

40. chemical equation: $H_2SO_4(aq) + 2KOH(aq) \rightarrow 2H_2O(l) + K_2SO_4(aq)$; complete ionic equation: $2H^+(aq) + \cancel{SO_4^{2-}(aq)} + \cancel{2K^+(aq)} + 2OH^-(aq) \rightarrow 2H_2O(l) + \cancel{2K^+(aq)} + \cancel{SO_4^{2-}(aq)}$; net ionic equation: $2H^+(aq) + 2OH^-(aq) \rightarrow 2H_2O(l)$, simplified to $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

41. chemical equation: $2HCl(aq) + Ca(OH)_2(aq) \rightarrow 2H_2O(l) + CaCl_2(aq)$; complete ionic equation: $2H^+(aq) + \cancel{2Cl^-(aq)} + \cancel{Ca^{2+}(aq)} + 2OH^-(aq) \rightarrow 2H_2O(l) + \cancel{Ca^{2+}(aq)} + \cancel{2Cl^-(aq)}$ net ionic equation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

42. chemical equation: $HNO_3(aq) + NH_4OH(aq) \rightarrow H_2O(l) + NH_4NO_3(aq)$ complete ionic equation: $H^+(aq) + \cancel{NO_3^-(aq)} + \cancel{NH_4^+(aq)} + OH^-(aq) \rightarrow H_2O(l) + \cancel{NH_4^+(aq)} + \cancel{NO_3^-(aq)}$; net ionic equation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

43. chemical equation: $H_2S(aq) + Ca(OH)_2(aq) \rightarrow 2H_2O(l) + CaS(aq)$; complete ionic equation: $2H^+(aq) + \cancel{S^{2-}(aq)} + \cancel{Ca^{2+}(aq)} + 2OH^-(aq) \rightarrow 2H_2O(l) + \cancel{Ca^{2+}(aq)} + \cancel{S^{2-}(aq)}$; net ionic equation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

44. chemical equation: $2C_6H_5COOH(aq) + Mg(OH)_2(aq) \rightarrow Mg(C_6H_5COO)_2(aq) + 2H_2O(l)$; complete ionic equation: $\cancel{2C_6H_5COO^-(aq)} + 2H^+(aq) + \cancel{Mg^{2+}(aq)} + 2OH^-(aq) \rightarrow \cancel{2C_6H_5COO^-(aq)} + \cancel{Mg^{2+}(aq)} + 2H_2O(l)$; net ionic equation: $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

Nora

5 & 6. Predict whether reactions in aqueous solutions will produce precipitate

REACTIONS THAT FORM A PRECIPITATE

Write the chemical, complete ionic, and net ionic equations for the reaction between aqueous solutions of barium nitrate and sodium carbonate that forms the precipitate barium carbonate.

$Ba(NO_3)_2\,(aq) + Na_2CO_3\,(aq) \rightarrow BaCO_3\,(s) + NaNO_3\,(aq)$

$Ba(NO_3)_2\,(aq) + Na_2CO_3\,(aq) \rightarrow BaCO_3\,(s) + 2NaNO_3\,(aq)$ Balance the skeleton equation.

$Ba^{2+}\,(aq) + 2NO_3^-\,(aq) + 2Na^+\,(aq) + CO_3^{2-}\,(aq) \rightarrow BaCO_3\,(s) + 2Na^+\,(aq) + 2NO_3^-\,(aq)$ Show the ions of the reactants and the products.

$Ba^{2+}\,(aq) + \cancel{2NO_3^-\,(aq)} + \cancel{2Na^+\,(aq)} + CO_3^{2-}\,(aq) \rightarrow BaCO_3\,(s) + \cancel{2Na^+\,(aq)} + \cancel{2NO_3^-\,(aq)}$ Cross out the spectator ions from the complete ionic equation.

$Ba^2 + (aq) + CO_3^{2-}\,(aq) \rightarrow BaCO_3\,(s)$ Write the net ionic equation.

ADDITIONAL PRACTICE

Write chemical, complete ionic, and net ionic equations for each of the following reactions that might produce a precipitate. Use *NR* to indicate that no reaction occurs.

35. Aqueous solutions of potassium iodide and silver nitrate are mixed, forming the precipitate silver iodide.

36. Aqueous solutions of ammonium phosphate and sodium sulfate are mixed. No precipitate forms and no gas is produced.

37. Aqueous solutions of aluminum chloride and sodium hydroxide are mixed, forming the precipitate aluminum hydroxide.

38. Aqueous solutions of lithium sulfate and calcium nitrate are mixed, forming the precipitate calcium sulfate.

39. CHALLENGE When aqueous solutions of sodium carbonate and manganese(V) chloride are mixed, a precipitate forms. The precipitate is a compound containing manganese.

35. chemical equation: $KI(aq) + AgNO_3(aq) \rightarrow KNO_3(aq) + AgI(s)$; complete ionic equation: $K^+(aq) + I^-(aq) + Ag^+(aq) + NO_3^-(aq) \rightarrow K^+(aq) + NO_3^-(aq) + AgI(s)$; net ionic equation: $I^-(aq) + Ag^+(aq) \rightarrow AgI(s)$

36. chemical equation: $2(NH_4)_3PO_4(aq) + 3Na_2SO_4(aq) \rightarrow 3(NH_4)_2SO_4(aq) + 2Na_3PO_4(aq)$; complete ionic equation: $6NH_4^+(aq) + 2PO_4^{3-}(aq) + 6Na^+(aq) + 3SO_4^{2-}(aq) \rightarrow 6NH_4^+(aq) + 3SO_4^{2-}(aq) + 6Na^+(aq) + 2PO_4^{3-}(aq)$
No reaction occurs; therefore, there is no net ionic equation.

37. chemical equation: $AlCl_3(aq) + 3NaOH(aq) \rightarrow Al(OH)_3(s) + 3NaCl(aq)$; complete ionic equation: $Al^{3+}(aq) + 3Cl^-(aq) + 3Na^+(aq) + 3OH^-(aq) \rightarrow Al(OH)_3(s) + 3Na^+(aq) + 3Cl^-(aq)$ net ionic equation: $Al^{3+}(aq) + 3OH^-(aq) \rightarrow Al(OH)_3(s)$

38. chemical equation: $Li_2SO_4(aq) + Ca(NO_3)_2(aq) \rightarrow 2LiNO_3(aq) + CaSO_4(s)$; complete ionic equation: $2Li^+(aq) + SO_4^{2-}(aq) + Ca^{2+}(aq) + 2NO_3^-(aq) \rightarrow 2Li^+(aq) + 2NO_3^-(aq) + CaSO_4(s)$; net ionic equation: $SO_4^{2-}(aq) + Ca^{2+}(aq) \rightarrow CaSO_4(s)$

39. chemical equation: $5Na_2CO_3(aq) + 2MnCl_5(aq) \rightarrow 10NaCl(aq) + Mn_2(CO_3)_5(s)$; complete ionic equation: $10Na^+(aq) + 5CO_3^{2-}(aq) + 2Mn^{5+}(aq) + 10Cl^-(aq) \rightarrow 10Na^+(aq) + 10Cl^-(aq) + Mn_2(CO_3)_5(s)$; net ionic equation: $5CO_3^{2-}(aq) + 2Mn^{5+}(aq) \rightarrow Mn_2(CO_3)_5(s)$

Nora

5 & 6. Predict whether reactions in aqueous solutions will produce precipitate

What is the **net ionic equation** for the following reaction?

$CaCl_{2\,(aq)} + 2NaOH_{(aq)} \rightarrow 2NaCl_{(aq)} + C$

Learning Outcomes Covered

- CHM.5.3.01.003
- CHM.5.3.01.011
- CHM.5.3.01.013
- CHM.5.3.01.014
- CHM.5.3.01.020

a. $2Na^{+}_{(aq)} + 2Cl^{-}_{(aq)} \rightarrow 2NaCl_{(aq)}$

b. $Ca^{2+}_{(aq)} + 2OH^{-}_{(aq)} \rightarrow Ca(OH)_{2(s)}$

c. $Ca^{2+}_{(aq)} + 2OH^{-}_{(aq)} \rightarrow Ca_{(s)} + O_{2\,(g)} + H_{2\,(g)}$

d. $Ca^{2+}_{(aq)} + 2Cl^{-}_{(aq)} + 2Na^{+}_{(aq)} + 2OH^{-}_{(aq)} \rightarrow 2Na^{+}_{(aq)} + 2Cl^{-}_{(aq)} + Ca(OH)_{2(s)}$

11. Identify the mole relationships shown by a chemical formula

EXAMPLE Problem 6

MOLE RELATIONSHIPS FROM A CHEMICAL FORMULA Aluminum oxide (Al_2O_3), often called alumina, is the principal raw material for the production of aluminum (Al). Alumina occurs in the minerals corundum and bauxite. Determine the moles of aluminum ions (Al^{3+}) in 1.25 mol of Al_2O_3.

1. ANALYZE THE PROBLEM

You are given the number of moles of Al_2O_3 and must determine the number of moles of Al^{3+} ions. Use a conversion factor based on the chemical formula that relates moles of Al^{3+} ions to moles of Al_2O_3. Every mole of Al_2O_3 contains 2 mol of Al^{3+} ions. Thus, the answer should be two times the number of moles of Al_2O_3.

Known	Unknown
number of moles = 1.25 mol Al_2O_3	number of moles = ? mol Al^{3+} ions

2. SOLVE FOR THE UNKNOWN

Use the relationship that 1 mol of Al_2O_3 contains 2 mol of Al^{3+} ions to write a conversion factor.

$$\frac{2\ \text{mol Al}^{3+}\ \text{ions}}{1\ \text{mol Al}_2\text{O}_3}$$

Create a conversion factor relating moles of Al^{3+} ions to moles of Al_2O_3.

To convert the known number of moles of Al_2O_3 to moles of Al^{3+} ions, multiply by the ions-to-moles conversion factor.

$$\text{moles Al}_2\text{O}_3 \times \frac{2\ \text{mol Al}^{3+}\ \text{ions}}{1\ \text{mol Al}_2\text{O}_3} = \textbf{moles Al}^{3+}\ \textbf{ions}$$ Apply the conversion factor.

$$1.25\ \text{mol Al}_2\text{O}_3 \times \frac{2\ \text{mol Al}^{3+}\ \text{ions}}{1\ \text{mol Al}_2\text{O}_3} = \textbf{2.50 mol Al}^{3+}\ \textbf{ions}$$ Substitute moles Al_2O_3 = 1.25 mol Al_2O_3 and solve.

Nora

11. Identify the mole relationships shown by a chemical formula

29. Zinc chloride $(ZnCl_2)$ is used in soldering flux, an alloy used to join two metals together. Determine the moles of Cl^- ions in $2.50\ mol\ ZnCl_2$.

30. Plants and animals depend on glucose $(C_6H_{12}O_6)$ as an energy source. Calculate the number of moles of each element in $1.25\ mol\ C_6H_{12}O_6$.

31. Iron(III) sulfate $[Fe_2(SO_4)_3]$ is sometimes used in the water purification process. Determine the number of moles of sulfate ions present in $3.00\ mol$ of $Fe_2(SO_4)_3$.

32. How many moles of oxygen atoms are present in $5.00\ mol$ of diphosphorus pentoxide (P_2O_5)?

33. CHALLENGE Calculate the number of moles of hydrogen atoms in $1.15 \times 10^1\ mol$ of water. Express the answer in scientific notation.

29. $5.00\ mol\ Cl^-$
30. $7.50\ mol\ C$; $15.0\ mol\ H$; $7.50\ mol\ O$
31. $9.00\ mol\ SO_4^{2-}$
32. $25.0\ mol\ O$
33. $2.30 \times 10^1\ mol\ H$

Nora

13. Explain what is meant by the percentage composition of the compound

EXAMPLE Problem 10

CALCULATING PERCENT COMPOSITION

Sodium hydrogen carbonate ($NaHCO_3$), also called baking soda, is an active ingredient in some antacids used for the relief of indigestion. Determine the percent composition of $NaHCO_3$.

2. SOLVE FOR THE UNKNOWN

Determine the molar mass of $NaHCO_3$ and each element's contribution.

$$1\ \cancel{\text{mol Na}} \times \frac{22.99\ \text{g Na}}{1\ \cancel{\text{mol Na}}} = 22.99\ \text{g Na}$$

Multiply the molar mass of Na by the number of Na atoms in the compound.

$$1\ \cancel{\text{mol H}} \times \frac{1.008\ \text{g H}}{1\ \cancel{\text{mol H}}} = 1.008\ \text{g H}$$

Multiply the molar mass of H by the number of H atoms in the compound.

$$1\ \cancel{\text{mol C}} \times \frac{12.01\ \text{g C}}{1\ \cancel{\text{mol C}}} = 12.01\ \text{g C}$$

Multiply the molar mass of C by the number of C atoms in the compound.

$$3\ \cancel{\text{mol O}} \times \frac{16.00\ \text{g O}}{1\ \cancel{\text{mol O}}} = 48.00\ \text{g O}$$

Multiply the molar mass of O by the number of O atoms in the compound.

$$\text{molar mass} = (22.99\ \text{g} + 1.008\ \text{g} + 12.01\ \text{g} + 48.00\ \text{g})$$

$$= 84.01\ \text{g/mol NaHCO}_3$$

Total the mass values.

Use the percent by mass equation.

$$= \frac{\text{mass of element in 1 mole of compound}}{\text{molar mass of compound}} \times 100$$

$$\text{percent Na} = \frac{22.99\ \text{g}}{\text{mol/84.01 g/mol}} \times 100 = 27.37\%\ \text{Na}$$

$$\text{percent H} = \frac{1.008\ \text{g}}{\text{mol/84.01 g/mol}} \times 100 = 1.200\%\ \text{H}$$

$$\text{percent C} = \frac{12.01\ \text{g}}{\text{mol/84.01 g/mol}} \times 100 = 14.30\%\ \text{C}$$

$$\text{percent O} = \frac{48.00\ \text{g}}{\text{mol/84.01 g/mol}} \times 100 = 57.14\%\ \text{O}$$

Nora

13. Explain what is meant by the percentage composition of the compound

ADDITIONAL PRACTICE

54. What is the percent composition of phosphoric acid (H_3PO_4)?

55. Which has the larger percent by mass of sulfur, H_2SO_3 or $H_2S_2O_8$?

56. Calcium chloride ($CaCl_2$) is sometimes used as a de-icer. Calculate the percent by mass of each element in $CaCl_2$.

57. CHALLENGE Sodium sulfate is used in the manufacture of detergents.

- **a.** Identify each of the component elements of sodium sulfate, and write the compound's chemical formula.
- **b.** Identify the compound as ionic or covalent.
- **c.** Calculate the percent by mass of each element in sodium sulfate.

54. 3.08% H; 31.61% P; 65.31% O

55. H_2SO_3

56. 36.11% Ca; 63.89% Cl

57. a. sodium, sulfur, and oxygen; Na_2SO_4
    b. ionic
    c. 32.37% Na; 22.58% S; 45.05% O

Nora

13. Explain what is meant by the percentage composition of the compound

What is the percent by mass of sodium (Na) in sodium sulfate (Na_2SO_4)?

يوم في

Molar mass:
Na = 23 g/mol
Na_2SO_4 = 119 g/mol

Learning Outcomes Covered

- CHM.5.3.01.009

a. 19.3%

b. 23.1%

c. 38.7%

d. 77.3%

14. determine of the empirical and molecular formulas for a compound from mass percent

Empirical formula - the <u>simplest whole number</u> ratio of atoms of each element present in a compound

shown in **Figure 13,** where 100.00 g of the compound contains 40.05 g of S and 59.95 g of O. Each mass is then converted to moles.

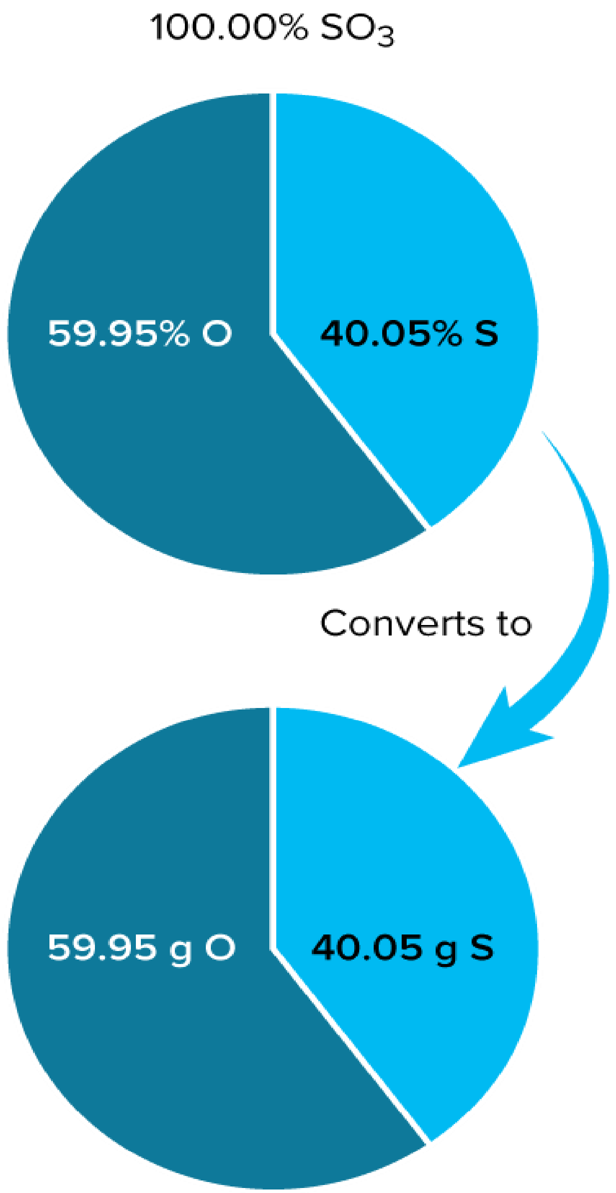
$$40.05\ \cancel{g\ S} \times \frac{1\ \text{mol S}}{32.07\ \cancel{g\ S}} = 1.249\ \text{mol S}$$

$$59.95\ \cancel{g\ O} \times \frac{1\ \text{mol O}}{16.00\ \cancel{g\ O}} = 3.747\ \text{mol O}$$

Thus, the mole ratio of S atoms to O atoms in the oxide is 1.249:3.747. Since the values are not whole numbers, you convert the ratio to whole numbers by dividing by the smallest value. This does not change the ratio between the two elements because both are divided by the same number.

$$\frac{1.249\ \text{mol S}}{1.249} = 1\ \text{mol S} \qquad \frac{3.747\ \text{mol O}}{1.249} = 3\ \text{mol O}$$

Thus, the empirical formula is SO_3.



Nora

14. determine of the empirical and molecular formulas for a compound from mass percent

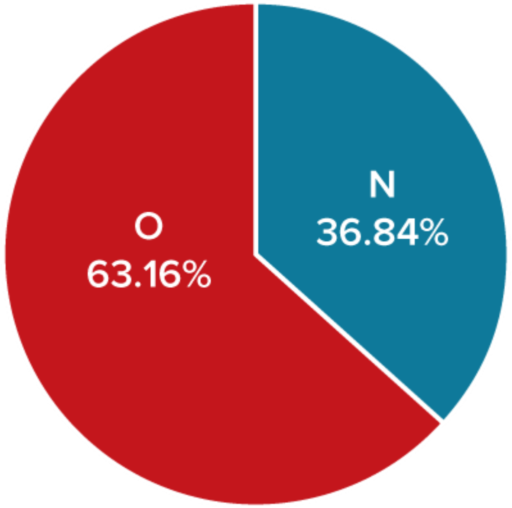
Molecular formula - the actual number of and type of atoms of each element in a molecule

Go through example problem 11 from the textbook page number 194

molecular formula = (empirical formula)n

e.g. C_4H_8 = (CH2)2.

58. The circle graph at the right gives the percent composition for a blue solid. What is the empirical formula for this solid?



59. Determine the empirical formula for a compound that contains 35.98% aluminum and 64.02% sulfur.

60. Propane is a hydrocarbon, a compound composed only of carbon and hydrogen. It is 81.82% carbon and 18.18% hydrogen. What is the empirical formula?

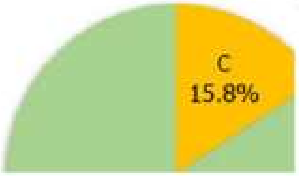
61. CHALLENGE Aspirin is the world's most-often used medication. The chemical analysis of aspirin indicates that the molecule is 60.00% carbon, 4.44% hydrogen, and 35.56% oxygen. Determine the empirical formula for aspirin.

58. N_2O_3
59. Al_2S_3
60. CH_3
61. $C_9H_8O_4$

Nora

14. determine of the empirical and molecular formulas for a compound from mass percent

What is the empirical formula for a compound with the following percent compositions shown in the pie chart below?



Learning Outcomes Covered

- CHM.5.3.01.009

a. CS_2

b. CS

c. CS_3

d. C_2S

Which one of the following is the empirical formula for N_2O_4?

Learning Outcomes Covered

- CHM.5.3.01.006

a. NO

b. N_2O

c. NO_2

d. N_2O_5

Nora

14. determine of the empirical and molecular formulas for a compound from mass percent

Which statement of the following is **correct** concerning molecular formula? ا يتعلق بالصيغة الجزيئية؟

1	It is the formula with the smallest whole-number mole ratio of the elements in a compound	عناصر المكونة للمركب بأبسط نسبة مولية بينها
2	It the same as empirical formula for some compounds	ية لبعض المركبات
3	It specifies the actual number of atoms of each element in one molecule or formula unit of the substance	كل عنصر في الجزيء الواحد أو وحدة الصيغة من المادة

Learning Outcomes Covered

- CHM.5.3.01.006

a. 1 only — 1 فقط

b. 3 only — 3 فقط

c. 1 & 2 only — 1 و 2 فقط

d. 2 & 3 only — 2 و 3 فقط

15. Identify the relationships can be derived from a balanced chemical equation

Use with Example Problem 1.

Problem

The combustion of propane (C_3H_8) provides energy for heating homes, cooking food, and soldering metal parts. Interpret the equation for the combustion of propane in terms of representative particles, moles, and mass. Show that the law of conservation of mass is observed.

SOLVE FOR THE UNKNOWN

The coefficients in the chemical equation indicate the number of molecules.

1 molecule C_3H_8 + 5 molecules O_2 → 3 molecules CO_2 + 4 molecules H_2O

The coefficients in the chemical equation also indicate the number of moles.

1 mol C_3H_8 + 5 mol O_2 → 3 mol CO_2 + 4 mol H_2O

SOLVE FOR THE UNKNOWN

To verify that mass is conserved, first convert moles of reactant and product to mass by multiplying by a conversion factor—the molar mass—that relates grams to moles.

$$\text{moles of reactant or product} \times \frac{\text{grams reactant or product}}{\text{1 mol reactant or product}} = \text{grams of reactant or product}$$

- Calculate the mass of the reactant C_3H_8.

$$1\ \cancel{\text{mol } C_3H_8} \times \frac{44.09\text{ g } C_3H_8}{1\ \cancel{\text{mol } C_3H_8}} = 44.09\ C_3H_8$$

- Calculate the mass of the reactant O_2.

$$5\ \cancel{\text{mol } O_2} \times \frac{32.00\text{ g } O_2}{1\ \cancel{\text{mol } O_2}} = 160.0\text{ g } O_2$$

- Calculate the mass of the reactant CO_2.

$$3\ \cancel{\text{mol } CO_2} \times \frac{44.01\text{ g } CO_2}{1\ \cancel{\text{mol } CO_2}} = 132.0\text{ g } CO_2$$

- Calculate the mass of the reactant H_2O.

$$4\ \cancel{\text{mol } H_2O} \times \frac{18.02\text{ g } H_2O}{1\ \cancel{\text{mol } H_2O}} = 72.08\text{ g } H_2O$$

- Add the masses of the reactants.

44.09 g C_3H_8 + 160.0 g O_2 = **204.1 g reactants**

- Add the masses of the products.

132.0 g CO_2 + 72.08 g H_2O = **204.1 g products**

- The law of conservation of mass is observed.

204.1 g reactants = 204.1 g products

Nora

15. Identify the relationships can be derived from a

1. Interpret the following balanced chemical equations in terms of particles, moles, and mass. Show that the law of conservation of mass is observed.
   a. $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
   b. $HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(l)$
   c. $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

2. **CHALLENGE** For each of the following, balance the chemical equation; interpret the equation in terms of particles, moles, and mass; and show that the law of conservation of mass is observed.
   a. ___$Na(s)$ + ___$H_2O(l) \rightarrow$ ___$NaOH(aq)$ + ___$H_2(g)$
   b. ___$Zn(s)$ + ___$HNO_3(aq) \rightarrow$ ___$Zn(NO_3)_2(aq)$ + ___$N_2O(g)$ + ___$H_2O(l)$

1. a. 34.062 g reactants = 34.062 g products
   b. 92.566 g reactants = 92.566 g products
   c. 80.608 g reactants = 80.608 g products
2. a. $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + 1H_2(g)$
   82.01 g reactants = 82.01 g products
   b. $4Zn(s) + 10HNO_3(aq) \rightarrow 4Zn(NO_3)_2(aq) + 1N_2O(g) + 5H_2O(l)$
   891.68 g reactants = 891.68 g products

Nora

16. Write the mole ratios from a balanced chemical equation

- Ratio between the numbers of moles of any two substances in a balanced chemical equation
  - $2Al(s) + 3Br_2(l) \rightarrow 2AlBr_3(s)$
- Possible to write 3 unique mole ratios:
  - $Al:Br_2$ (2:3) Al: $AlBr_3$ (2:2) $Br_2:AlBr_3$ (3:2)
- Get 3 more ratios from inverses of above for a total of **6** for this reaction

Nora

16. Write the mole ratios from a balanced chemical equation

3. Determine all possible mole ratios for the following balanced chemical equations.

a. $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$

b. $3Fe(s) + 4H_2O(l) \rightarrow Fe_3O_4(s) + 4H_2(g)$

c. $2HgO(s) \rightarrow 2Hg(l) + O_2(g)$

4. CHALLENGE Balance the following equations, and determine the possible mole ratios.

a. $ZnO(s) + HCl(aq) \rightarrow ZnCl_2(aq) + H_2O(l)$

b. butane (C_4H_{10}) + oxygen → carbon dioxide + water

3. a. $\frac{4 \text{ mol Al}}{3 \text{ mol } O_2}$ $\frac{3 \text{ mol } O_2}{2 \text{ mol } Al_2O_3}$ $\frac{2 \text{ mol } Al_2O_3}{4 \text{ mol Al}}$

$\frac{3 \text{ mol } O_2}{4 \text{ mol Al}}$ $\frac{2 \text{ mol } Al_2O_3}{3 \text{ mol } O_2}$ $\frac{4 \text{ mol Al}}{2 \text{ mol } Al_2O_3}$

b. $\frac{3 \text{ mol Fe}}{4 \text{ mol } H_2O}$ $\frac{3 \text{ mol Fe}}{4 \text{ mol } H_2}$ $\frac{3 \text{ mol Fe}}{1 \text{ mol } Fe_3O_4}$

$\frac{4 \text{ mol } H_2O}{3 \text{ mol Fe}}$ $\frac{4 \text{ mol } H_2}{3 \text{ mol Fe}}$ $\frac{1 \text{ mol } Fe_3O_4}{3 \text{ mol Fe}}$

$\frac{1 \text{ mol } Fe_3O_4}{4 \text{ mol } H_2}$ $\frac{1 \text{ mol } Fe_3O_4}{4 \text{ mol } H_2O}$ $\frac{4 \text{ mol } H_2O}{4 \text{ mol } H_2}$

$\frac{4 \text{ mol } H_2}{1 \text{ mol } Fe_3O_4}$ $\frac{4 \text{ mol } H_2O}{1 \text{ mol } Fe_3O_4}$ $\frac{4 \text{ mol } H_2}{4 \text{ mol } H_2O}$

$\frac{2 \text{ mol HgO}}{2 \text{ mol Hg}}$ $\frac{1 \text{ mol } O_2}{2 \text{ mol Hg}}$ $\frac{1 \text{ mol } O_2}{2 \text{ mol HgO}}$

$\frac{2 \text{ mol Hg}}{2 \text{ mol HgO}}$ $\frac{2 \text{ mol Hg}}{1 \text{ mol } O_2}$ $\frac{2 \text{ mol HgO}}{1 \text{ mol } O_2}$

4. a. $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$

$\frac{1 \text{ mol ZnO}}{2 \text{ mol HCl}}$ $\frac{1 \text{ mol ZnO}}{1 \text{ mol } ZnCl_2}$ $\frac{1 \text{ mol ZnO}}{1 \text{ mol } H_2O}$

$\frac{2 \text{ mol HCl}}{1 \text{ mol ZnO}}$ $\frac{2 \text{ mol HCl}}{1 \text{ mol } ZnCl_2}$ $\frac{2 \text{ mol HCl}}{1 \text{ mol } H_2O}$

$\frac{1 \text{ mol } ZnCl_2}{1 \text{ mol ZnO}}$ $\frac{1 \text{ mol } ZnCl_2}{2 \text{ mol HCl}}$ $\frac{1 \text{ mol } ZnCl_2}{1 \text{ mol } H_2O}$

$\frac{1 \text{ mol } H_2O}{1 \text{ mol ZnO}}$ $\frac{1 \text{ mol } H_2O}{2 \text{ mol HCl}}$ $\frac{1 \text{ mol } H_2O}{1 \text{ mol } ZnCl_2}$

b. $2C_4H_{10} + 13O_2 \rightarrow 8CO_2 + 10H_2O$

$\frac{2 \text{ mol } C_4H_{10}}{13 \text{ mol } O_2}$ $\frac{2 \text{ mol } C_4H_{10}}{8 \text{ mol } CO_2}$ $\frac{2 \text{ mol } C_4H_{10}}{10 \text{ mol } H_2O}$

$\frac{13 \text{ mol } O_2}{2 \text{ mol } C_4H_{10}}$ $\frac{8 \text{ mol } CO_2}{2 \text{ mol } C_4H_{10}}$ $\frac{10 \text{ mol } H_{10}}{2 \text{ mol } C_4H_{10}}$

$\frac{10 \text{ mol } H_2}{13 \text{ mol } O_2}$ $\frac{10 \text{ mol } H_2}{8 \text{ mol } CO_2}$ $\frac{8 \text{ mol } CO_2}{13 \text{ mol } O_2}$

$\frac{13 \text{ mol } O_2}{10 \text{ mol } H_2O}$ $\frac{8 \text{ mol } CO_2}{10 \text{ mol } H_2O}$ $\frac{13 \text{ mol } O_2}{8 \text{ mol } CO_2}$

Nora

16. Write the mole ratios from a balanced chemical equation

Stoichiometry is based on the law of .... تستند على قانون ....

Learning Outcomes Covered

- CHM.5.3.01.009
- CHM.5.3.01.011

a. Constant mole ratios ولية لثابتة

b. Avogadro's constant جادروا

c. Conservation of energy اقة

d. Conservation of mass ة

What is the correct balanced skeleton equation that represents the chemical reaction below? غ الصحيحة التي تُمثل

Hydrochloric acid (HCl) reacts with solid Aluminum (Al) metal to yield aqueous Aluminum chloride ($AlCl_3$) and Hydrogen gas (H_2) (HCl) مع فلز الالمنيوم الصلب (Al) م ($AlCl_3$) وغاز الهيدروجين (H_2)

Learning Outcomes Covered

- CHM.5.3.01.013
- CHM.5.3.01.014

a. $2Al_{(s)} + 6HCl_{(aq)} \rightarrow 2AlCl_{3\,(aq)} + 3H_{2\,(g)}$

b. $2Al_{(s)} + 6HCl_{(g)} \rightarrow 2AlCl_{3\,(l)} + 3H_{2\,(aq)}$

c. $2AlCl_{3\,(aq)} + 3H_{2\,(g)} \rightarrow 2Al_{(s)} + 6HCl_{(aq)}$

d. $3Al_{(aq)} + 3HCl_{(aq)} \rightarrow 3AlCl_{3\,(aq)} + 3H_{2\,(g)}$

Nora

16. Write the mole ratios from a balanced chemical equation

In the equation below,

Which of the following mole ratio is **NOT** correct? لتالية ليست صحيحة؟

$$4A + 3B \rightarrow 2C$$

Learning Outcomes Covered

- CHM.5.3.01.003
- CHM.5.3.01.011
- CHM.5.3.01.013
- CHM.5.3.01.014

a. $\frac{4\ mol\ A}{3\ mol\ B}$

b. $\frac{4\ mol\ A}{2\ mol\ C}$

c. $\frac{2\ mol\ C}{3\ mol\ B}$

d. $\frac{3\ mol\ C}{2\ mol\ B}$

17 & 18. Apply the steps to solve stoichiometric problems

EXAMPLE Problem 2

MOLE-TO-MOLE STOICHIOMETRY One disadvantage of burning propane (C_3H_8) is that carbon dioxide (CO_2) is one of the products. The released carbon dioxide increases the concentration of CO_2 in the atmosphere. How many moles of CO_2 are produced when 10.0 mol of C_3H_8 are burned in excess oxygen in a gas grill?

1. ANALYZE THE PROBLEM

You are given moles of the reactant, C_3H_8 and must find the moles of the product, CO_2. First write the balanced chemical equation, then convert from moles of C_3H_8 to moles of CO_2. The correct mole ratio has moles of unknown substance in the numerator and moles of known substance in the denominator.

Known

moles C_3H_8 = 10.0 mol C_3H_8

Unknown

moles CO_2 = ? mol CO_2

2. SOLVE FOR THE UNKNOWN

Write the balanced chemical equation for the combustion of C_3H_8. Use the correct mole ratio to convert moles of known (C_3H_8) to moles of unknown (CO_2).

10.0 mol ? mol

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$$

Mole ratio: $\frac{3 \text{ mol } CO_2}{1 \text{ mol } C_3H_8}$

$$10.0 \text{ mol } C_3H_8 \times \frac{3 \text{ mol } CO_2}{1 \text{ mol } C_3H_8} = 30.0 \text{ mol } CO_2$$

Burning 10.0 moles of C_3H_8 produces 30.0 moles CO_2.

11. Methane and sulfur react to produce carbon disulfide (CS_2), a liquid often used in the production of cellophane.

___ $CH_4(g)$ + ___ $S_8(s)$ → ___ $CS_2(l)$ + ___ $H_2S(g)$

a. Balance the equation.

b. Calculate the moles of CS_2 produced when 1.50 mol S_8 is used.

c. How many moles of H_2S are produced?

12. CHALLENGE Sulfuric acid (H_2SO_4) is formed when sulfur dioxide (SO_2) reacts with oxygen and water.

a. Write the balanced chemical equation for the reaction.

b. How many moles of H_2SO_4 are produced from 12.5 moles of SO_2?

c. How many moles of O_2 are needed?

11. a. $2CH_4(g) + S_8(s) \rightarrow 2CS_2(l) + 4H_2S(g)$

b. $1.50 \text{ mol } S_8 \times \frac{2 \text{ mol } CS_2}{1 \text{ mol } S_8} = 3.00 \text{ mol } CS_2$

c. $1.50 \text{ mol } S_8 \times \frac{4 \text{ mol } H_2S}{1 \text{ mol } S_8} = 6.00 \text{ mol } H_2S$

12. a. $2SO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 2H_2SO_4(aq)$

b. $12.5 \text{ mol } SO_2 \times \frac{2 \text{ mol } H_2SO_4}{2 \text{ mol } SO_2} = 12.5 \text{ mol } H_2SO_4$ produced

c. $12.5 \text{ mol } SO_2 \times \frac{1 \text{ mol } O_2}{2 \text{ mol } SO_2} = 6.25 \text{ mol } O_2$ needed

Nora

17 & 18. Apply the steps to solve stoichiometric problems

EXAMPLE Problem 3

MOLE-TO-MASS STOICHIOMETRY Determine the mass of sodium chloride ($NaCl$), commonly called table salt, produced when 1.25 mol of chlorine gas (Cl_2) reacts vigorously with excess sodium.

1. ANALYZE THE PROBLEM

You are given the moles of the reactant, Cl_2, and must determine the mass of the product, $NaCl$. You must convert from moles of Cl_2 to moles of $NaCl$ using the mole ratio from the equation. Then, you need to convert moles of $NaCl$ to grams of $NaCl$ using the molar mass as the conversion factor.

Known	Unknown
moles of chlorine = 1.25 mol Cl_2	mass of sodium chloride =? g NaCl

2. SOLVE FOR THE UNKNOWN

$$\overset{1.25\text{ mol}}{} \quad \overset{?\text{ g}}{}$$
$$2Na(s) + Cl_2(g) \rightarrow 2NaCl(s)$$

Write the balanced chemical equation, and identify the known and the unknown values.

$$\text{Mole ratio: } \frac{2\text{ mol NaCl}}{1\text{ mol }Cl_2}$$

Multiply moles of Cl_2 by the mole ratio to get moles of $NaCl$.

$$1.25\ \cancel{\text{mol }Cl_2} \times \frac{2\text{ mol NaCl}}{1\ \cancel{\text{mol }Cl_2}} = 2.50\text{ mol NaCl}$$

Multiply moles of $NaCl$ by the molar mass to get grams of $NaCl$.

$$2.50\ \cancel{\text{mol NaCl}} \times \frac{58.44\text{ g NaCl}}{1\ \cancel{\text{mol NaCl}}} = 146\text{ g NaCl}$$

13. Sodium chloride is decomposed into the elements sodium and chlorine by means of electrical energy. How much chlorine gas, in grams, is obtained from the process diagrammed at right?

14. CHALLENGE Titanium is a transition metal used in many alloys because it is extremely strong and lightweight. Titanium tetrachloride ($TiCl_4$) is extracted from titanium oxide (TiO_2) using chlorine and coke (carbon).

$$TiO_2(s) + C(s) + 2Cl_2(g) \rightarrow TiCl_4(s) + CO_2(g)$$

a. What mass of Cl_2 gas is needed to react with 1.25 mol of TiO_2?

b. What mass of C is needed to react with 1.25 mol of TiO_2?

c. What is the mass of all of the products formed by reaction with 1.25 mol of TiO_2?

13. 88.6 g Cl_2

14. a. 177 g Cl_2

b. 15.0 g C

c. 292 g

Nora

17 & 18. Apply the steps to solve stoichiometric problems

EXAMPLE Problem 4

MASS-TO-MASS STOICHIOMETRY Ammonium nitrate (NH_4NO_3), an important fertilizer, produces dinitrogen monoxide (N_2O) gas and H_2O when it decomposes. Determine the mass of H_2O produced from the decomposition of 25.0 g of solid NH_4NO_3.

1. ANALYZE THE PROBLEM

Write the balanced equation and convert the known mass of the reactant to moles of the reactant. Next, use a mole ratio to relate moles of the reactant to moles of the product. Then, use the molar mass to convert from moles of the product to the mass of the product.

Known	Unknown
mass of ammonium nitrate = 25.0 g NH_4NO_3	mass of water = ? g H_2O

2. SOLVE FOR THE UNKNOWN

$$\overset{25.0\ g}{NH_4NO_3(s)} \rightarrow N_2O(g) + \overset{?\ g}{2H_2O(g)}$$

Write the balanced chemical equation, and identify the known and unknown values.

$$25.0\ g\ NH_4NO_3 \times \frac{1\ mol\ NH_4NO_3}{80.04\ g\ NH_4NO_3} = 0.312\ mol\ NH_4NO_3$$

Multiply grams of NH_4NO_3 by the inverse of molar mass to get moles of NH_4NO_3.

$$\text{Mole ratio: } \frac{2\ mol\ H_2O}{1\ mol\ NH_4NO_3}$$

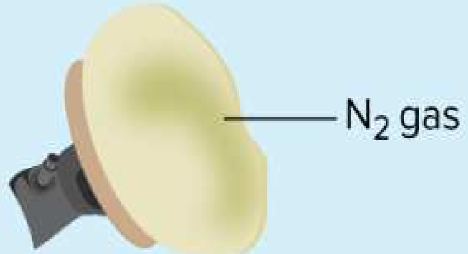
$$0.312\ mol\ NH_4NO_3 \times \frac{2\ mol\ H_2O}{1\ mol\ NH_4NO_3} = 0.624\ mol\ H_2O$$

Multiply moles of NH_4NO_3 by the mole ratio to get moles of H_2O.

$$0.624\ mol\ H_2O \times \frac{18.02\ g\ H_2O}{1\ mol\ H_2O} = 11.2\ g\ H_2O$$

Multiply moles of H_2O by the molar mass to get grams.

15. One of the reactions used to inflate automobile air bags involves sodium azide (NaN_3): $2NaN_3(s) \rightarrow 2Na(s) + 3N_2(g)$. Determine the mass of N_2 produced from the decomposition of NaN_3 shown below.



100.0 g $NaN_3 \rightarrow$? g $N_2(g)$

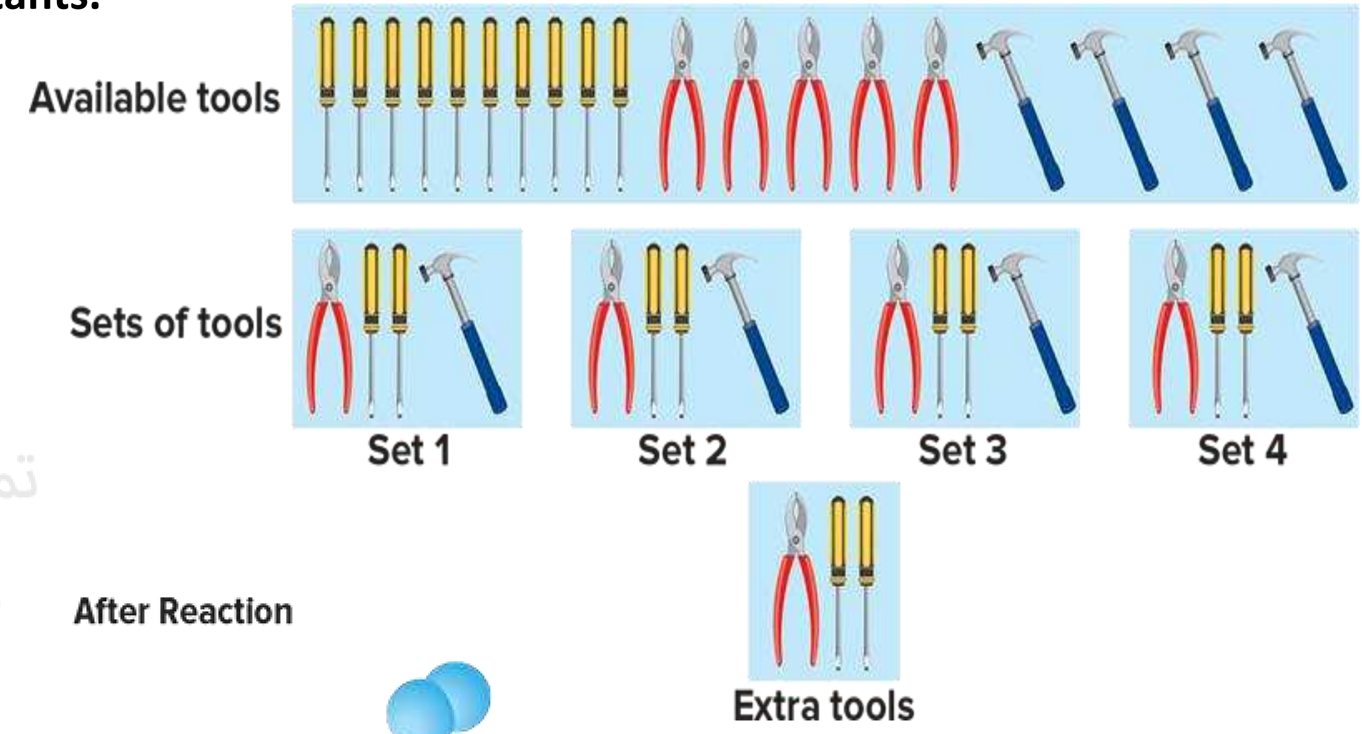
16. CHALLENGE In the formation of acid rain, sulfur dioxide (SO_2) reacts with oxygen and water in the air to form sulfuric acid (H_2SO_4). Write the balanced chemical equation for the reaction. If 2.50 g of SO_2 reacts with excess oxygen and water, how much H_2SO_4, in grams, is produced?

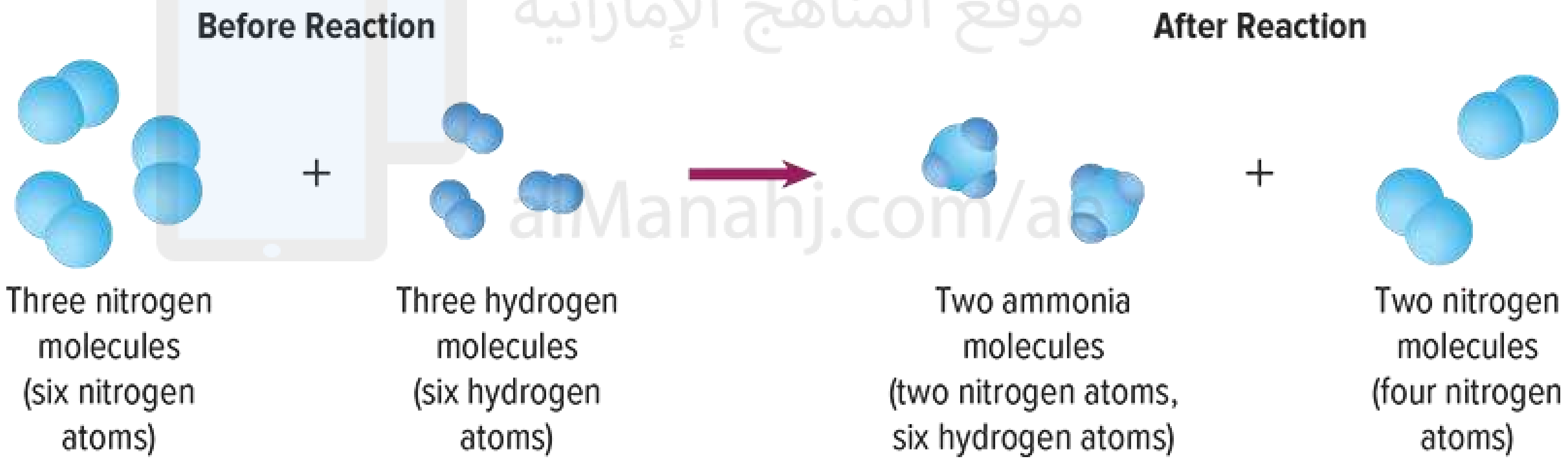
15. 64.64 g N_2

16. $2SO_2(g) + O_2(g) + 2H_2O(l) \rightarrow 2H_2SO_4(aq)$; 3.83 g H_2SO_4

19. Determine the limiting reactant In a chemical reaction

- The limiting reactant is the reactant that is completely consumed during a chemical reaction. Reactants that remain after the reaction stops are called excess reactants.





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19. Determine the limiting reactant In a chemical reaction

23. The reaction between solid sodium and iron(III) oxide is one in a series of reactions that inflates an automobile airbag: $6Na(s) + Fe_2O_3(s) \rightarrow 3Na_2O(s) + 2Fe(s)$. If 100.0 g of Na and 100.0 g of Fe_2O_3 are used in this reaction, determine the following.

a. limiting reactant

b. reactant in excess

c. mass of solid iron produced

d. mass of excess reactant that remains after the reaction is complete

24. CHALLENGE Photosynthesis reactions in green plants use carbon dioxide and water to produce glucose $(C_6H_{12}O_6)$ and oxygen. A plant has 88.0 g of carbon dioxide and 64.0 g of water available for photosynthesis. Be sure to report the correct level of accuracy based on measurements given in the question.

a. Write the balanced chemical equation for the reaction.

b. Determine the limiting reactant and the excess reactant.

c. Determine the mass in excess.

d. Determine the mass of glucose produced.

Go through example problem 5 from the textbook page number 227

23. a. Fe_2O_3 b. Na
c. 69.92 g Fe d. 13.6 g Na

24. a. $6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$
b. CO_2 is limiting; H_2O is in excess.
c. 28.0 g
d. 60.0 g

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20. Calculate of the theoretical yield of a chemical reaction

EXAMPLE Problem 6

PERCENT YIELD Solid silver chromate (Ag_2CrO_4) forms when excess potassium chromate (K_2CrO_4) is added to a solution containing 0.500 g of silver nitrate ($AgNO_3$). Determine the theoretical yield of Ag_2CrO_4. Find the percent yield if the reaction yields 0.455 g of Ag_2CrO_4.

1. ANALYZE THE PROBLEM

You know the mass of a reactant and the actual yield of the product. Write the balanced chemical equation, and calculate theoretical yield by converting grams of $AgNO_3$ to moles of $AgNO_3$, moles of $AgNO_3$ to moles of Ag_2CrO_4, and moles of Ag_2CrO_4 to grams of Ag_2CrO_4. Calculate the percent yield from the actual yield and the theoretical yield.

Known	Unknown
mass of silver nitrate = 0.500 g $AgNO_3$	theoretical yield = ? g Ag_2CrO_4
actual yield = 0.455 g Ag_2CrO_4	percent yield = ? % Ag_2CrO_4

2. SOLVE FOR THE UNKNOWN

$$\underset{0.500\text{ g}}{2AgNO_3(aq)} + K_2CrO_4(aq) \rightarrow \underset{?\text{ g}}{Ag_2CrO_4(s)} + 2KNO_3(aq)$$

Write the balanced chemical equation, and identify the known and the unknown.

$$0.500\ \text{g AgNO}_3 \times \frac{1\ \text{mol AgNO}_3}{169.9\ \text{g AgNO}_3} = 2.94 \times 10^{-3}\ \text{mol AgNO}_3$$

Convert grams of $AgNO_3$ to moles.

$$2.94 \times 10^{-3}\ \text{mol AgNO}_3 \times \frac{1\ \text{mol Ag}_2\text{CrO}_4}{2\ \text{mol AgNO}_3} = 1.47 \times 10^{-3}\ \text{mol Ag}_2\text{CrO}_4$$

Use the mole ratio to convert moles of $AgNO_3$ to moles of Ag_2CrO_4.

$$1.47 \times 10^{-3}\ \text{mol Ag}_2\text{CrO}_4 \times \frac{331.7\ \text{g Ag}_2\text{CrO}_4}{1\ \text{mol Ag}_2\text{CrO}_4} = 0.488\ \text{g Ag}_2\text{CrO}_4$$

Calculate the theoretical yield.

$$\frac{0.455\ \text{g Ag}_2\text{CrO}_4}{0.488\ \text{g Ag}_2\text{CrO}_4} \times 100 = 93.2\%\ \text{Ag}_2\text{CrO}_4$$

Calculate the percent yield.

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20. Calculate of the theoretical yield of a chemical reaction

28. Aluminum hydroxide ($Al(OH)_3$) is often present in antacids to neutralize stomach acid (HCl). The reaction occurs as follows: $Al(OH)_3\ (s) + 3HCl\ (aq) \rightarrow AlCl_3\ (aq) + 3H_2O\ (l)$. If $14.0\ g$ of $Al(OH)_3$ is present in an antacid tablet, determine the theoretical yield of $AlCl_3$ produced when the tablet reacts with HCl.

29. Zinc reacts with iodine in a synthesis reaction: $Zn + I_2 \rightarrow ZnI_2$.

a. Determine the theoretical yield if $1.912\ mol$ of zinc is used.

b. Determine the percent yield if $515.6\ g$ of product is recovered.

28. 23.9 g of $AlCl_3$ is the theoretical yield.
29. a. 610.3 g ZnI_2
 b. 84.48% yield of ZnI_2
30. a. $Cu(s) + 2AgNO_3(aq) \rightarrow 2Ag(s) + Cu(NO_3)_2(aq)$
 b. 68.0 g of Ag
 c. 88.2% yield

30. CHALLENGE When copper wire is placed into a silver nitrate solution ($AgNO_3$), silver crystals and copper(II) nitrate ($Cu(NO_3)_2$) solution form.

a. Write the balanced chemical equation for the reaction.

b. If a 20.0-g sample of copper is used, determine the theoretical yield of silver.

c. If $60.0\ g$ of silver is recovered from the reaction, determine the percent yield of the reaction.

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All the Best

https://t.me/+Bsnl6d0uTVthNDY8

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