Diaprof ProWS 002

Subject: Chemistry

Main Title: The Basics of Chemistry

Sub-title Details: Mole Calculations/Excess and Limiting Reagents

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1. If 10g of magnesium (Mg) reacts with 20g of hydrochloric acid (HCl) according to the balanced equation $Mg + 2HCl \rightarrow MgCl_2 + H_2$,
   (a) which reagent is the limiting reagent and
   (b)how much of the excess reagent remains after the reaction is complete?

Solutions

(i) Determine the excess/limiting reagent

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

From the equation:

1 mole of Mg requires 2 mole of HCl

But

$$\text{Mole} = \frac{\text{mass}}{\text{molar mass}}$$

Mass of Mg = 1mol x 24g/mol = 24g

Mass of HCl = 2mol x 36.5g/mol = 73g

Therefore,

From the equation:

24g of Mg →73g of HCl

10g of Mg →? g of HCl

$$\text{Mass of HCl} = \frac{10g \times 73g}{24g}$$

$= 30.42g$

Therefore, 10g of Mg would require 30.42g of HCl. Unfortunately there are only 20g, therefore, **HCl is the limiting reagent.**

(b) To determine the amount of the excess reagent remained:

Let us know how much of the amount of excess reagent reacted with the limiting reagent available.

From the equation:

24g of Mg → 73g of HCl

? g of Mg → 20g of HCl

$$\text{Mass of Mg} = \frac{24g \times 20g}{73g}$$

$= 6.58g$ (This is the amount of excess Mg reacted with HCl available)

Therefore the amount of excess Mg remained = 10g - 6.58g = **3.42g**

2. (a) How many moles of nitrogen monoxide gas (NO) are produced when 2.5 moles of ammonia (NH_3) react with 1.5 moles of oxygen gas (O_2) according to the balanced equation $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$?
   (b)Which reagent in 2(a) above is the limiting reagent and how many moles of the excess reagent remain after the reaction is complete?

Solution

(i) Use stoichiometry relationship to determine the excess/limiting reagent:

$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$
4 moles of $NH_3 \rightarrow$ 5 moles of O_2
2.5 moles of $NH_3 \rightarrow$? moles of O_2

$$\text{Moles of } O_2 = \frac{2.5\text{mol} \times 5\text{mol}}{4\text{mol}}$$
$$= 3.125\text{mol}$$

(a)The amount of product is determined by the limiting reagent, for this case is oxygen.
It follows that,

5 moles of $O_2 \rightarrow$ 4 moles of NO
1.5 moles of $O_2 \rightarrow$? moles of NO

$$\text{Moles of NO} = \frac{1.5\text{mol} \times 4\text{mol}}{5\text{ mol}}$$
$$= 1.2 \text{ moles}$$

1.2 moles of NO will be produced.

(b)(i) **Oxygen is the limiting agent.**

(ii) To calculate the amount of excess reagent remained:

5 moles of $O_2 \rightarrow$ 4 moles of NH_3
1.5 moles of $O_2 \rightarrow$? moles of NH_3

$$\text{Moles of } NH_3 = \frac{1.5\text{mol} \times 4\text{ mol}}{5\text{ mol}}$$
$$= 1.2 \text{ mol}$$

These 1.2 moles of NH_3 reacted with oxygen.

$\rightarrow$ 2.5 moles - 1.2 moles = **1.3 moles remained**

3. A chemist wants to react 25 g of sulfur (S) with 50 g of oxygen gas (O_2) to produce sulfur dioxide (SO_2) according to the balanced equation $S + O_2 \rightarrow SO_2$.
   (i) Which reagent is the limiting reagent and
   (ii) how much of the excess reagent remains after the reaction is complete?
4. Sodium reacts with chlorine gas according to the equation $2Na + Cl_2 \rightarrow 2NaCl$. If 10g of sodium (Na) were allowed to react with 20 g of chlorine gas (Cl_2)
   (a) How many grams of sodium chloride (NaCl) are produced?
   (b) Which reagent is the limiting reagent
   (c)How many grams of the excess reagent remain after the reaction is complete?

   (Relative *atomic masses, Cl = 35.5, Na=23)*

5. A student wants to react 25 mL of 0.2 M hydrochloric acid (HCl) with 50 mL of 0.1 M sodium hydroxide (NaOH) to produce water (H_2O) and sodium chloride (NaCl) according to the balanced equation $HCl + NaOH \rightarrow NaCl + H_2O$. Which reagent is the limiting reagent and how many moles of the excess reagent remain after the reaction is complete?
6. How many grams of carbon dioxide (CO_2) are produced when 50.0 g of propane (C_3H_8) react with 100.0 g of oxygen gas (O_2) according to the balanced equation $C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O$? Which reagent is the limiting reagent and how many grams of the excess reagent remain after the reaction is complete?

   (*Use the following relative atomic masses: C = 12, H =1*)

7. Methane (CH_4) reacts with chlorine gas (Cl_2) to produce carbon tetrachloride (CCl_4) and hydrogen chloride (HCl). If the chemical equation for the reaction is:

   $CH_4 + 4Cl_2 \rightarrow CCl_4 + 4HCl$

The chemical reactants present are 10 grams of CH_4 and 100 grams of Cl_2, which is the limiting reagent?

8. Ammonia (NH_3) reacts with oxygen (O_2) to produce nitrogen (N_2) and water (H_2O). The summary for this reaction is:

   $4NH_3 + 3O_2 \rightarrow 2N_2 + 6H_2O$

   If you have 50 grams of NH_3 and 50 grams of O_2, what will be the limiting reagent in this reaction?

9. In a reaction, 10 grams of hydrogen gas (H_2) and 15 grams of oxygen gas (O_2) are combined. If the balanced equation requires 2 moles of H_2 and 1 mole of O_2, which reactant is the limiting reagent?
   Answer: Oxygen gas (O2) is the limiting reagent.
10. If 20 grams of methane (CH_4) and 30 grams of carbon dioxide (CO_2) are combined, and the balanced equation requires 1 mole of CH_4 and 1 mole of CO_2, how many grams of the excess reagent will be left over after the reaction is complete?
    Answer: 16 grams of carbon dioxide (CO_2) will be left over.
11. You are a chemical engineer working in a manufacturing plant that produces ammonia (NH_3) using the Haber process. The plant needs to produce 850 grams of ammonia for an industrial order. You have a reactor that is currently loaded with 500 grams of hydrogen gas (H_2) and 1000 grams of nitrogen gas (N_2). Your task is to determine the quantities of reactants required and identify the limiting reagent to optimize the production process.
    The chemical equation for the Haber process is:
    $N_2 + 3H_2 \rightarrow 2NH_3$
12. Glucose ($C_6H_{12}O_6$) reacts with oxygen (O_2) to produce carbon dioxide (CO_2) and water (H_2O) according to equation $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$. If 180 grams of glucose and 192 grams of oxygen were mixed together and allowed to react, which is the limiting reagent? How much carbon dioxide is produced?

13. In a reaction where 16 grams of oxygen (O_2) react with 12 grams of hydrogen (H_2) to form water (H_2O), determine which substance is the limiting reagent and calculate the maximum amount of water that can be produced. (Hint: Use the relative atomic masses of O=16, H=1)
14. A chemist mixes 140 grams of sodium chloride (NaCl) with 100 grams of silver nitrate ($AgNO_3$) in a double displacement reaction to produce sodium nitrate ($NaNO_3$) and silver chloride (AgCl). Identify the limiting reagent and calculate how much silver chloride is produced.
15. A chemical reaction requires 9 grams of magnesium (Mg) and 32 grams of sulphur (S) to produce magnesium sulphide (MgS). Determine the excess reagent and calculate how much magnesium sulphide is formed.
16. In an industrial process, 300 grams of carbon (C) and 400 grams of oxygen (O_2) are combined to produce carbon dioxide (CO_2). Which substance will be the limiting reagent, and what is the maximum amount of carbon dioxide that can be produced?
17. A student performs a reaction involving 15 grams of hydrogen (H_2) and 100 grams of nitrogen (N_2) to produce ammonia (NH_3). Determine the limiting reagent and calculate the amount of ammonia produced.
18. For a reaction producing sodium hydroxide (NaOH) from sodium (Na) and water (H_2O), 23 grams of sodium (Na) and 18 grams of water (H_2O) are used. What is the limiting reagent, and calculate the amount of sodium hydroxide produced.
19. In the anodizing process 15.0 grams of aluminum (Al) and 20.0 grams of oxygen (O_2) were allowed to react. The chemical equation for the reaction is: $4Al+3O_2 \rightarrow 2Al_2O_3$

(a) Identify the limiting reagent.
(b) Calculate the amount of aluminum oxide (Al_2O_3) produced.
(c) Determine the amount of excess reagent remaining.

20. Three moles of nitrogen gas combine with five moles of hydrogen gas to form ammonia gas by Haber process.
    (a) Which reactant is present in smaller amount?
    (b) Calculate the grams of the reactant left in the container.
    (c) How many moles of NH_3 are produced?
    (d) How many litres of NH_3 are produced at S.T.P? (NECTA, 2018)