LIMITING REACTIONS

Answer all the questions below and then check your answers.

1. What is a limiting factor in a chemical reaction?

2. Which reactant determines the amount of product formed in a chemical reaction?

3. In a reaction, if 3 moles of A react with 2 moles of B to form product C, and A is in excess, which is the limiting reactant?

4. Define the term "limiting reactant" in the context of a chemical reaction.

5. Explain why identifying the limiting reactant is important in a chemical reaction.

6. How do you determine the limiting reactant in a chemical reaction?

7. A reaction between 4 moles of hydrogen and 2 moles of oxygen produces water. Identify the limiting reactant and justify your answer.

8. In the Haber process for making ammonia (NH_3) nitrogen and hydrogen gases react according to the equation below:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

If hydrogen is a limiting factor here what will happen to the yield of ammonia if more nitrogen is added?

9. Describe the steps to solve a limiting reactant problem and illustrate with the reaction of ethene gas with oxygen to form carbon dioxide and water vapour; as shown below:

If you have 5 moles of C_2H_4 and 12 moles of O_2, identify the limiting reactant and calculate the amount of CO_2 produced.

10. Which of the following statements is true about the limiting reactant?

a) It is always the reactant present in the smallest quantity.

b) It determines the amount of product formed in a reaction.

c) It is the reactant that remains after the reaction is complete.

d) It has no effect on the theoretical yield of a product.

11. In a reaction where $2A + B \rightarrow 3C$, if you start with 4 moles of A and 2 moles of B, what is the limiting reactant?

a) A b) B c) C d) None of these

12. Match the following terms to their definitions:

Factor	Definition
Limiting reactant	The maximum amount of product that could be formed from given amounts of reactants
Excess reactant	The amount of product actually produced by a reaction.
Theoretical yield	The reactant that is completely consumed in a reaction, limiting the amount of product formed.
Actual yield	The reactant that is not completely consumed in a reaction

13. Fill in the gaps to complete the sentences below:

In a chemical reaction, the _____ reactant is completely used up first and thus limits the amount of _____ formed.

b. To determine the _____ reactant, compare the mole ratio of the reactants used to the mole ratio in the _____ equation.

14. Given the reaction shown below:

$$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$$

If you start with 12 moles of Fe and 12 moles of H_2O, determine the limiting reactant and the amount of Fe_3O_4 produced.

Additional questions

15. Potassium reacts with chlorine according to the equation below:

$$2K + Cl_2 \rightarrow 2KCl$$

If you start with 6 moles of K and 2 moles of Cl_2, determine the limiting reactant and the amount of KCl produced.

16. Phosphorus reacts with oxygen according to the equation below:

$$4P + 5O_2 \rightarrow 2P_2O_5$$

If you start with 8 moles of P and 10 moles of O_2, determine the limiting reactant and the amount of P_2O_5 produced.

Answers

1. What is a limiting factor in a chemical reaction?

   Answer: The reactant that is completely used up first, limiting the amount of product formed.

2. Which reactant determines the amount of product formed in a chemical reaction?

   Answer: The limiting reactant.

3. In a reaction, if 3 moles of A react with 2 moles of B to form product C, and A is in excess, which is the limiting reactant?

   Answer: B.

4. Define the term "limiting reactant" in the context of a chemical reaction.
   Answer: The limiting reactant is the substance that is completely consumed in a reaction, thus determining the maximum amount of product that can be formed.

5. Explain why identifying the limiting reactant is important in a chemical reaction.

   Answer: Identifying the limiting reactant is important because it allows for the calculation of the maximum yield of product that can be obtained, ensuring that resources are used efficiently.

6. How do you determine the limiting reactant in a chemical reaction?

   Answer: To determine the limiting reactant, calculate the moles of each reactant present and compare them to the stoichiometric ratios (mole ratios) in the balanced chemical equation. The reactant that produces the least amount of product is the limiting reactant.

7. A reaction between 4 moles of hydrogen and 2 moles of oxygen produces water. Identify the limiting reactant and justify your answer.

Answer: The balanced equation is:

$$2H_2 + O_2 \rightarrow 2H_2O$$

According to the equation, 2 moles of H_2 react with 1 mole of O_2, that is the hydrogen and oxygen should be present in the ratio of 2:1. Therefore, 4 moles of H_2 would require 2 moles of O_2. Since the ratios match exactly, there is no limiting reactant; both reactants are completely used up.

8. In the Haber process for making ammonia (NH_3) nitrogen and hydrogen gases react according to the equation below:

$$N_2 + 3H_2 \rightarrow 2NH_3$$

If hydrogen is a limiting factor here what will happen to the yield of ammonia if more nitrogen is added?

Answer: If hydrogen is the limiting reactant, adding more nitrogen will not increase ammonia production. Identifying and controlling the limiting reactant ensures optimal use of raw materials and maximizes production efficiency.

9. Describe the steps to solve a limiting reactant problem and illustrate with the reaction of ethene gas with oxygen to form carbon dioxide and water vapour; as shown below:

$$\text{ethene} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{water}$$

$$C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$$

If you have 5 moles of C_2H_4 and 12 moles of O_2, identify the limiting reactant and calculate the amount of CO_2 produced.

Answer:

Step 1: Write the balanced equation: $C_2H_4 + 3O_2 \rightarrow 2CO_2 + 2H_2O$.

Step 2: Calculate the mole ratio needed: 1 mole C_2H_4 requires 3 moles O_2.

Step 3: Determine the moles of products each reactant can form.

For C_2H_4: 5 moles C_2H_4 can react with 15 moles O_2 (5 x 3 = 15).

For O_2: 12 moles O_2 can react with 4 moles C_2H_4 (12 / 3 = 4).

Step 4: Identify the limiting reactant: O_2 is limiting because only 4 moles of C_2H_4 can react.

Step 5: Calculate the product formed: 4 moles of C_2H_4 produce 8 moles of CO_2 (4 x 2 = 8). Answer: The limiting reactant is O_2, and the amount of CO_2 produced is 8 moles.

10. Which of the following statements is true about the limiting reactant?

a) It is always the reactant present in the smallest quantity.

b) It determines the amount of product formed in a reaction.

c) It is the reactant that remains after the reaction is complete.

d) It has no effect on the theoretical yield of a product.

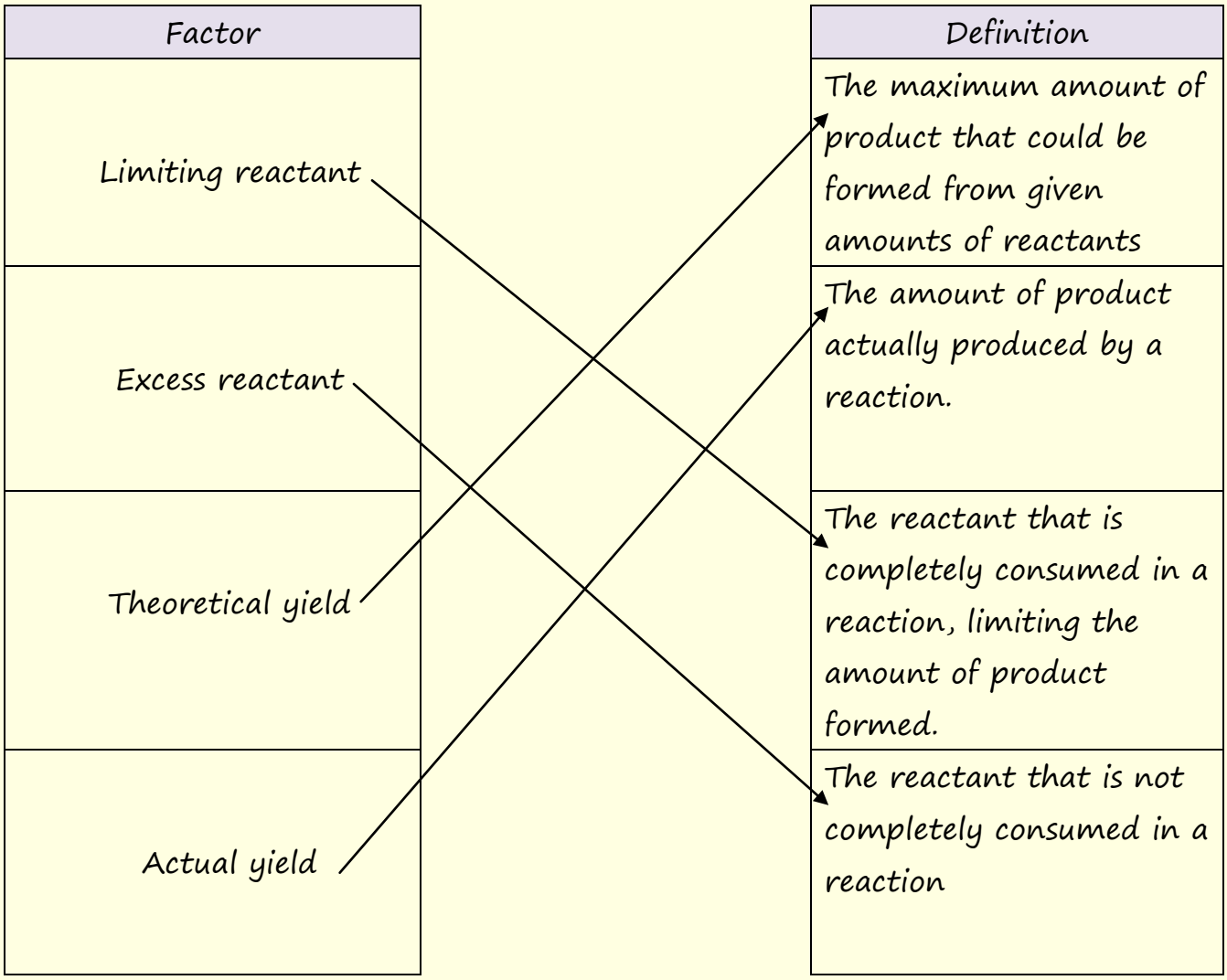
Answer: b) It determines the amount of product formed in a reaction.

11. In a reaction where $2A + B \rightarrow 3C$, if you start with 4 moles of A and 2 moles of B, what is the limiting reactant?

a) A b) B c) C d) None of these

Answer: b) B

12. Match the following terms to their definitions:



13. Fill in the gaps to complete the sentences below:

In a chemical reaction, the _____ reactant is completely used up first and thus limits the amount of _____ formed.

Answer: In a chemical reaction, the limiting reactant is completely used up first and thus limits the amount of product formed.

b. To determine the _____ reactant, compare the mole ratio of the reactants used to the mole ratio in the _____ equation.

Answer: To determine the limiting reactant, compare the mole ratio of the reactants used to the mole ratio in the balanced equation.

14. Given the reaction shown below:

$$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$$

If you start with 12 moles of Fe and 12 moles of H_2O, determine the limiting reactant and the amount of Fe_3O_4 produced.

Answer:

Balanced equation: $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$.

Mole ratio: 3 moles Fe react with 4 moles H_2O.

Fe to H_2O ratio: 12 moles Fe require 16 moles H_2O (12 x 4/3 = 16).

H_2O available: 12 moles.

Limiting reactant: H_2O.

Fe_3O_4 produced: 12 moles H_2O can form 3 moles Fe_3O_4 (12 x 1/4 = 3). Answer: The limiting reactant is H_2O, and 3 moles of Fe_3O_4 are produced.

Additional questions

15. Potassium reacts with chlorine according to the equation below:

$$2K + Cl_2 \rightarrow 2KCl$$

If you start with 6 moles of K and 2 moles of Cl_2, determine the limiting reactant and the amount of KCl produced.

Answer:

- Balanced equation: $2K + Cl_2 \rightarrow 2KCl$
- Mole ratio: 2 moles K reacts with 1 mole Cl_2
- Calculate moles of product for each reactant:
  - For K: 6 moles K would need 3 moles Cl_2 (6 / 2 = 3).
  - For Cl_2: 2 moles Cl_2 would need 4 moles K (2 x 2 = 4).
- Identify the limiting reactant: Cl_2 (because only 2 moles are available, while 3 moles are needed).
- Calculate the amount of KCl produced:
  - 2 moles Cl_2 can form 4 moles KCl (2 x 2 = 4).

Answer: The limiting reactant is Cl_2, and the amount of KCl produced is 4 moles.

16. Phosphorus reacts with oxygen according to the equation below:

$$4P + 5O_2 \rightarrow 2P_2O_5$$

If you start with 8 moles of P and 10 moles of O_2, determine the limiting reactant and the amount of P_2O_5 produced.

Answer:

Balanced equation: $4P + 5O_2 \rightarrow 2P_2O_5$

Mole ratio: 4 moles P reacts with 5 moles O_2

Calculate moles of product for each reactant:

For P: 8 moles P would need 10 moles O_2 (8 x 5/4 = 10).

For O_2: 10 moles O_2 would need 8 moles P (10 x 4/5 = 8).

Identify the limiting reactant: Both reactants are used up completely in this case.

Calculate the amount of P_2O_5 produced:

8 moles P can form 4 moles P_2O_5 (8 x 2/4 = 4).

10 moles O_2 can form 4 moles P_2O_5 (10 x 2/5 = 4). Answer: Both P and O_2 are completely used up, and the amount of P_2O_5 produced is 4 moles.