

# What Happens If I Run Out Of Ingredients (Reactants)?

## **Why?**

A baker is in a hurry to prepare a cake for a special order that has just been received. There is no time to go shopping so only the ingredients that are in the bakery can be used. What if one ingredient is short of the required amount called for in the recipe? Can a cake still be made? Yes, but will it be big enough? Stay tuned and find out.

## **Success Criteria**

- Be able to determine the limiting reactant (reagent) in a chemical reaction and determine the amount of product that can be produced.

## **Prerequisites**

- Chemical reaction equations and stoichiometric relationships

## **New Concept**

- Limiting reactants

## **Reference**







- David Hanson and Troy Wolfskill, "Process Workshops – A New Model for Instruction", *Journal of Chemical Education*, Vol. 77, pp120 – 130, January 2000.

**Model**

A cake recipe calls for:

|                     |                            |
|---------------------|----------------------------|
| <i>2 cups water</i> | <i>4 eggs</i>              |
| <i>4 cups sugar</i> | <i>8 oz butter</i>         |
| <i>4 cups flour</i> | <i>8 squares chocolate</i> |

Ingredients on hand:

|   |   |
|---|---|
| <br><i>lots of water</i> | <br><i>6 eggs</i>                  |
| <br><i>4 cups sugar</i>  | <br><i>16 oz butter</i>             |
| <br><i>5 cups flour</i> | <br><i>12 squares of chocolate</i> |

**Key Questions**

1. According to the model, how much of each ingredient is necessary to make a cake?

| <b>Water</b> | <b>Flour</b> | <b>Chocolate</b> | <b>Sugar</b> | <b>Butter</b> | <b>Eggs</b> |
|--------------|--------------|------------------|--------------|---------------|-------------|
|              |              |                  |              |               |             |

2. If you follow the recipe, using only the ingredients on hand in the model, how much of each ingredient will be left over after you have prepared the cake?

| <b>Water</b> | <b>Flour</b> | <b>Chocolate</b> | <b>Sugar</b> | <b>Butter</b> | <b>Eggs</b> |
|--------------|--------------|------------------|--------------|---------------|-------------|
|              |              |                  |              |               |             |

3. Which ingredients on hand were in excess of the quantities required for the recipe?
4. Which ingredient on hand was completely consumed when making the cake?
5. Which ingredient limits or prevents you from making a larger cake?
6. If only two eggs are available when a cake is being made, fill in the chart to indicate the quantity of each of the other ingredients will be used in order to maintain the same ratio between all of the components in the cake.

| <b>Water</b> | <b>Flour</b> | <b>Chocolate</b> | <b>Sugar</b> | <b>Butter</b> | <b>Eggs</b> |
|--------------|--------------|------------------|--------------|---------------|-------------|
|              |              |                  |              |               |             |

7. If the cake is made with the ingredients as shown in question 6, how will the size of the cake compare to the cake made with the ingredients shown in question 1?
8. Based on information presented in the model, what is meant by the term limiting reactant (ingredient or reagent)?

## Exercises

1. Describe a procedure that could be used to identify the limiting component in a manufacturing process.

*Test your procedure by answering the following questions:*

2. You want to make 10 dozen standard-size cookies as specified by a recipe that requires 16 oz butter, 4 eggs, 3 cups flour and 4 cups sugar. When taking inventory of your supplies you find that you have 16 oz butter, 6 eggs, 3 cups of flour, and 3 cups of sugar.
  - a. Which ingredient will limit the number of cookies you can make?
  - b. How many standard-size cookies can you make?
3. You have 100 bolts, 150 nuts and 150 washers. You assemble a nut/bolt/washer set using the following recipe or equation:  $2 \text{ washers} + 1 \text{ bolt} + 1 \text{ nut} = 1 \text{ set}$ 
  - a. How many sets can you make from your supply?
  - b. Which is the limiting component?
4. 150  $\text{H}_2$  molecules and 100  $\text{O}_2$  molecules are reacted to produce water. This reaction is described by the following recipe or reaction equation:  $2 \text{ H}_2 + \text{O}_2 \rightarrow 2 \text{ H}_2\text{O}$ 
  - a. How many water molecules can you produce from your supply of hydrogen and oxygen?
  - b. Which is the limiting reactant?
5. If you had 100 molecules of  $\text{H}_2$  instead of 150 molecules of  $\text{H}_2$ , but still had 100 molecules of  $\text{O}_2$ , how many water molecules could you produce?

6. If you had 500  $\text{H}_2$  molecules and 1000  $\text{O}_2$  molecules, how many water molecules could you produce?
  
  
  
  
  
  
  
  
  
  
7. If you had 500  $\text{H}_2$  molecules, how many  $\text{O}_2$  molecules would you need to completely react all of the  $\text{H}_2$ ?
  
  
  
  
  
  
  
  
  
  
8. *Do not solve the following problem, but explain how it could be answered.*  
500 g of  $\text{H}_2$  and 1000 g  $\text{O}_2$  are placed in a reaction vessel. How many **grams** of water could be produced?