Chapter 6: Quantities in Chemical Reactions

October 6, 2022

Chemistry Department, Cypress College

Class Annoucements

Lecture

- Keep submitting the homework assignment on time ($\sim 1-2$ hours grace period)
- Go over homework 4 - present and get 1 EC point
- Quiz submissions are slacking (Quiz 5 due tonight at 11:59pm)
- Homework and Quiz will be released Fri, Oct 7 at 3pm

Outline

Limiting Reactant/Reagent

Percent Yield, Theoretical Yield, and Actual

Application: Baking a Cake

Peach Zefir Torte

I cannot say enough about how delicious this delicate peach and zefir cake is! This has been one of my favorite cakes since childhood. It's made with simple sponge cake, whipped cream, peaches and Russian marshmallow, which is unlike any other kind! Zefir is made with agar gelatin, which results in a meringue-marshmallow that sets at room temperature and simply melts in your mouth. This cake is delicate, fluffy and simply divine!

Prep Time: 2 Hours • Bake Time: 20 Minutes

For Cake Layers

6 large eggs
¾ cup (150 g) sugar
1 tsp vanilla extract
1 cup (125 g) all-purpose flour
¼ cup (25 g) almond flour
1 tsp baking powder

For Whipped Cream

1½ cups (355 ml) heavy cream, chilled
1 cup (125 g) confectioners' sugar
1 tsp vanilla extract

For Filling

1½ cups (355 ml) peach preserves
½ cup (118 ml) moscato or sweet wine

For Zefir

¾ cup (178 ml) water, divided
¼ cup (45 g) peach-flavored gelatin powder
2 tsp (16 g) agar gelatin
2 cups (400 g) sugar
3 large egg whites
1 tbsp (15 ml) lemon juice

2 large peaches, diced, for layers

1. Preheat the oven to 350°F (177°C). Line three 8-inch (20-cm) cake pans with parchment paper.
2. Prepare the whipped cream in a large bowl, whisk together the eggs, sugar and vanilla on high speed for 4 to 6 minutes, until pale and voluminous. In a separate bowl, combine the dry ingredients: flour, almond flour and baking powder. Sift the dry ingredients into the eggs, folding gently but thoroughly.
3. Divide the batter evenly among the three pans and bake for 20 minutes, until golden brown. Allow the layers to cool completely, then use a serrated knife to split each layer in half.
4. Prepare the whipped cream: in a large bowl, whisk together the heavy cream, confectioners' sugar and vanilla for 3 to 4 minutes, until stiff peaks form.
5. For the peach filling, combine the peach preserves and wine in a small bowl.
6. Prepare the zefir last. In a small saucepan, combine ¼ cup (60 ml) water and the peach gelatin. Cook over medium heat for several minutes, until the gelatin is dissolved, then set aside.
7. Combine the remaining ½ cup (118 ml) water and agar gelatin in a separate saucepan. Cook over medium heat for several minutes, until the mixture begins to simmer. Gradually add the sugar and continue to cook the syrup over medium heat until it begins to boil; boil for 2 minutes.
8. Whisk the egg whites in a stand mixer bowl on high speed for a minute, until soft peaks form. Pour the syrup in a steady stream into the egg whites with the mixer running on medium speed. Add the peach gelatin mixture and lemon juice last, then whisk on high speed for 6 to 8 minutes, until the mixture thickens and pulls away from the sides.
9. Fill a large pastry bag tipped with a star tip #4FT or #8FT. This cake can be assembled in a tall springform pan or on a cake stand. Spread the peach filling and a generous amount of whipped cream over the first layer, then top with a second cake layer. Pipe a layer of zefir, top with diced peaches, then pipe more zefir over the top, sandwiching the peaches inside. Proceed to assemble the cake, alternating with layers of sponge cake, peach filling, whipped cream, sponge cake and zefir. Garnish the top of the cake with dollops of zefir.

Approaching Limiting Reactant Problems

$$\mathrm{R1} + \mathrm{R2} \rightarrow \mathrm{P1} \tag{1}$$

- Given a certain amount of each reagents (R1 and R2) to produce P1, determine how much the R2 is needed to completely react with R1
- Based on that calculated value, determine whether there is enough R2 to completely react with R1
- If the amount of R2 is less than what is needed, then R2 is the limiting
- If the amount of R2 is more than what is needed, then R2 is the excess

Example: Limiting Reactant/Reagent

Ethylene, C_2H_4, undergoes many useful reactions. However, it is highly flammable and burns in the presence of oxygen. Suppose a mixture of 0.25 mol C_2H_4 and 1.0 mol O_2 leads to a combustion. Determine the limiting reactant, excess reactant and amount of CO_2 formed in mols.

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Since C_2H_4 is the **limiting reagent**

$$0.25\text{mol } C_2H_4 \times \frac{2\text{mol } CO_2}{1\text{mol } C_2H_4} = 0.5\text{mol } CO_2$$

Example: Double-Displacement Reaction

Aqueous silver nitrate and magnesium chloride reacts to form silver chloride and magnesium nitrate. Suppose a scientist mix 25mL of 1.0M silver nitrate with 25mL of 1.0M magnesium chloride. Identify the limiting reactant and the number of moles of silver chloride formed.

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$$0.025\text{L} \times 1.0\text{M } AgNO_3 \times \frac{1\text{mol } MgCl_2}{2\text{mol } AgNO_3} = 0.0125\text{mol } MgCl_2$$

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$$0.025L \times 1.0M\ AgNO_3 \times \frac{1mol\ MgCl_2}{2mol\ AgNO_3} = 0.0125mol\ MgCl_2$$

Since $MgCl_2$ is the **excess** and $AgNO_3$ is the **limiting reagent**

$$0.025mol\ AgNO_3 \times \frac{2mol\ AgCl}{2mol\ AgNO_3} = 0.025mol\ AgCl$$

Outline

Percent Yield, Theoretical Yield, and Actual

Percent Yield - describes how much product has been produced

$$\% = \frac{\text{actual yield}}{\text{theoretical yield}} \times 100\% \tag{2}$$

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Actual Yield - the amount produced in the lab (potential errors)

Theoretical Yield - the maximum amount predicted from a given amount of reagents

Example: Percent Yield

Sodium metal reacts with water in a single displacement reaction to produce a metal hydroxide and a gas. When 0.50 mol Na is placed in water, all the sodium metal reacts, and the gas produced is isolated. It is determined that 0.21 mol of the gas has been produced. What is the percent yield of H_2?

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$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

$$0.50\text{mol Na} \times \frac{1\text{mol } H_2}{2\text{mol Na}} = 0.25\text{mol } H_2$$

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$$0.50\text{mol Na} \times \frac{1\text{mol } H_2}{2\text{mol Na}} = 0.25\text{mol } H_2$$

$$\% = \frac{0.21\text{mol } H_2}{0.25\text{mol } H_2} \times 100\%$$

$$= 84\%$$