Lesson 3-4: Rates of Reaction.	
Curriculum Expectations	D3.5, D3.6, D3.7, D2.8
Learning Goals	By the end of this lesson you will be able to: • describe what rate of reaction means • explain collision theory in the context of chemical reactions • explain how different factors, including temperature, concentration, pressure and catalysts impact the rate of a reaction • understand how the rate limiting step impacts the rate of a reaction
Success Criteria	I know I have achieved the goals of this lesson when I can define rate of reaction, describe collision theory and how it can be applied to understand the changes in rates of reaction when different variables are adjusted and can identify the rate limiting step in and describe how this step affects the rate of reaction.
Teacher Prep	• Check to see that rates of reaction simulator works on your computer. • Print out materials from "Sinking of the Kursk" activity. • Print out exit cards.

Minds On

Goal: To introduce the concept of rates as they relate to chemical reactions.

1. <u>Class Discussion</u>

- Begin the lesson by having a brief class discussion in which you ask the class if they can offer examples of things that are measured by their rate. Record responses on the board. (sample responses may include: speed of a car, growth of a person/plant/animal, rate of change)

- After you have compiled a list of several examples, follow up by asking and recording the responses of each next to each example.
    - "What type of units are those rates measured in?
    - "Which tools can be used to measure those rates"

- Ask the class if those rates are constant for each example or if the rates change and can be changed by external factors. The idea is to have students understand that the rate of change is not necessarily a fixed value, that rates can be changed by internal and external factors.
    - Example: "Is the rate that a car moves at fixed?" "How can the speed of a car be changed?"

- (sample answer: stepping on the accelerator/break, by traveling on different surfaces, engine breakdown, wind, etc.)

- Conclude the discussion by introducing the concept of reaction rates:
  - "Chemical reactions can also be described by their rate of reaction, which is also called the reaction rate"

2. <u>Think-Pair-Share</u>

- Pair up students (or groups of 3-4) for a think-pair-share activity.

Prompt 1: "How would the rate of a reaction be measured (which units and tools could you use)?"

1. Have each person in each group carefully think about the prompt for **2 minutes**.
2. Than have each student record their answer on a sheet of paper.
3. Have students reflect on which connections they can make to previous knowledge.
4. Have the pairs (or groups) come together to share their ideas for 3-4 minutes and discuss the prompt. The students should ask questions to help clarify what each was thinking.
5. As the teacher, you should circulate around the room while this is going on, help facilitate the discussion and make sure students are staying on topic.
6. After sufficient time, groups will choose one member to share their ideas with the rest of the class.
7. Record responses and help guide the students to the fact that the rate of a chemical reaction can be measured by the amount of product produced over a period of time.

Prompt 2: "Why might a predicted chemical reaction fail to occur? (For example a match head fails to light when struck)"

1. Have each person in each group carefully think about the prompt for **2 minutes**.
2. Than have each student record their answers on a sheet of paper.
3. Have students reflect on which connections they can make to previous knowledge.
4. Have the pairs (or groups) come together to share their ideas for 3-4 minutes and discuss the prompt. The students should ask questions to help clarify what each was thinking.
5. As the teacher, you should circulate around the room while this is going on, help facilitate the discussion and make sure students are staying on topic.
6. After sufficient time, groups will choose one member to share their ideas with the rest of the class.

Record responses and help guide the students to the idea that conditions (such as temperature, concentrations, energy) must be right for a reaction to occur to completion.

Action

1. **Introduction to Reaction Rates – Activity 3-4A**
   - Write the general formula for a reaction on the board;

     [Reactants] → [Products]

   - Have students read individually the description of rates of reaction and the formula to calculate it at the beginning of activity 3-4A: Rates of reaction.
   - After giving time for students to read the description ask if there are any questions.
   - Write the formula for solving for rate of reaction on the board.
   - Describe that a rate is something that describes a change over time and that for a chemical reaction, the rate is described as the change in the concentration of products divided by the time it takes for that change to occur.

     Δ[Reactants]/Δtime

2. **Reaction Rate Simulator Part 1**
   - Explain to the class that you will now explore reaction rates using an interactive simulator.
   - Have students open the "Rate of Reaction" simulator by clicking on the icon on the activity page. If there is difficulty opening the simulator, try opening from the source website: phet.colorado.edu
   - Give students 5 minutes to explore the "Single Collision" tab on the simulator on their own.
   - Instruct them to try out all the different reactions on the right hand menu and to observe the different measurements available to them.
   - You should also open the simulator and project it on to a screen for the whole class to see if possible.
   - After 5 minutes ask students for the observations from the simulator. Examples of guiding questions to use:
   - "How did you know if a reaction took place or not?"
   - "How did changing the temperature affect the reaction?"
   - "What is the relationship between energy and the reaction going to completion?"

3. **Collision Theory & Activation Energy**

   - Give students 10 minutes to read the sections on Collision Theory & Activtation Energy and follow up by asking if there are any questions.
   - Points of emphasis:
   - For a reaction to occur, reactant molecules must interact with each other (collision theory) with a sufficient amount of energy (activation energy).

4. **Factors Affecting Reaction Rate Simulator Part 2.**

- Have students select the "Rate Experiments" tab on the simulator.
  Explain the different tools available to them to manipulate the conditions and the data they can collect:
    - Initial concentration of reactants and products.
    - Initial Temperature
    - Timer
    - Final concentrations (as an amount or relative percentage using the different chart options.
- Give students 15 minutes to explore the simulator, instruct them to play around with different conditions to observe how these factors affect reaction rate.
- Have students discuss their observations when changing the different factors.
- After summarizing their results have the groups discuss why they think these factors impacted the reaction rate.
- One member of each group will summarize their observations and reasons underlying their observations.

5. <u>Factors Affecting Reaction Rate</u>

- Students will read explanations and watch accompanying videos for factors affecting reaction rate.
- Take up as a class the underlying reasons for these factors. Emphasize the connection between how increases in the reaction rate are related to either increases in the number of collisions, increases in the energy of the collisions or a reduction in the activation energy.

6. <u>Factors Affecting Reaction Rate – Virtual Labs (3-4B, 3-4C, 3-4D)</u>

The next set of instructions applies for the following series of learning activities:

a) 3-4B Factors Affecting Reaction Rate – Temperature Lab
b) 3-4C Factors Affecting Reaction Rate – Concentration Lab
c) 3-4B Factors Affecting Reaction Rate – Particle Size Lab

Note that these labs are meant to follow a guided inquiry process where limited instructions are given. Instead, students will understand the goal of the lab, explore the tools and design an experiment to meet the goals of the lab. Students should record their data using accurate data tables that include proper headings and units.

- Students will complete a set of virtual labs to help explore how different factors impact the rate of reaction.
- These labs should be completed by students individually, in groups or the teacher may project the lab on a screen and take the class through step-by-step.
- Students should record their results.

6a. Teachers Notes – Temperature Lab

- Students will measure reaction rate by recording the time it takes for an antacid to dissolve.
- They can adjust the temperature by adding ice or increasing/decreasing the temperature using the dial on the hot plate.
- A thermometer is available to accurately record temperatures.
- A timer is available to record the time.

Temperature: increase in temperature leads to an increase in the number of collisions as well as an increase in the energy of each collision. Both these factors contribute to an increase in reaction rate. The opposite is true when temperature is reduced.

6b. Teachers Notes – Concentration Lab

- Students will measure reaction rate by recording the time it takes for a magnesium ribbon to dissolve in varying concentrations of sulfuric acid.
- Concentration can be adjusted using the slider.
- A timer is available to record the time.
- After the lab is complete have students present their results and explain the underlying reasons for these results.

Concentration: increase in sulfuric acid concentration allows for more collisions to occur which will increase the rate.

6c. Teachers Notes – Particle Size Lab

- In this lab students will measure reaction rate by measuring the time it takes for zinc to dissolve in sulfuric acid depending on the size of the zinc particles.
- Particles of different size are available for selection from the cupboard.
- After the lab is complete have students present their results and explain the underlying reasons for these results.

Concentration: smaller particles allow for a greater surface area to interact with the sulfuric acid allowing for an increase in collisions and an increase in reaction rate.

7. <u>GROUP ACTIVITY – What Sank the Kursk Reaction Rate Investigation.</u>

- Give each student a copy of the news timeline to read and give 15-30 mins for students to read, so that they have an answer to the question 'What sank the Kursk nuclear submarine?'

    1. Ask what they have found from reading the ***News timeline***. Note: *Many points come up here but they should include that the sinking of the Kursk involved hydrogen peroxide.*
    2. Project or display the **Seismic Data Table**

3. Arrange students in pairs and ask the pairs to write down what information they can deduce from the table. Answer: *There were two explosions at roughly the same place in quick succession, the second more powerful than the first.*
4. Give a copy of **Peroxide Power in Torpedoes** to each student. They are to read the three reports and to answer the questions that follow.
5. Circulate and support the students while they work in groups to share their answers, agree on a final group answer and record what they have learned from the text. work in groups
6. As a class discuss the answers to the questions.

Consolidation

1. 3-4F - Rates of Reaction Practice Questions

- This worksheet contains a series of questions that will test the understanding of how reaction rates are measured, the terms used to describe reaction rates, the factors that affect reaction rates, and how the rate limiting step relates to reaction rates. Students may complete this worksheet in class with the teacher circulating to provide support. After an adequate amount of time, the answer should be taken up as a class
- or this can be assigned as homework. The following class the teacher should ask if there are any specific questions about the homework and then take up the answers to the worksheet, allowing for questions and discussion as they arise.

2. 3-4G: Interpreting Rates of Reaction Graphs

- This activity will test the understanding of rates of reaction and the factors that affect these rates by interpreting experimental conditions and the resulting graphs produced by those experiment. This activity helps students visualize how the results of a rate of reaction experiment would be displayed and will further connections between reaction rates and the factors that impact them.
- As an alternative, you could have students predict the graphs just by hearing or reading the descriptions provided and then show them the options to see if they match their predictions.
- This activity should be followed up by a discussion as to the relationship between the conditions described in the text and the resulting graphs.

3. Exit Card

- Print out the following on an exit card and hand to students as they leave to be brought in the following class. This question aims to reinforce the concept that a reaction cannot successfully occur unless a collision occurs with the proper orientation and sufficient activation energy.

Exit Card Question:

"Think of an everyday activity, such as a handshake, unlocking a lock, looking in a microscope, etc. that requires you to come in contact with something, be lined up

correctly, and to have a certain amount of energy to successfully complete the activity. Describe the activity and explain what would happen if any one of these criteria were not met. “

4. Assessment - Rates of Reaction Simulator Lab

- Read through the instructions for the lab with the students. Ensure that they understand all instructions and identify where the marks are allocated and how they will be assessed.
- Students must complete this assignment on their own and as a result the results they produce will be slightly different from each other.
- Students who are found to be copying from each other will receive a failing grade.