

Rates of Chemical Reactions

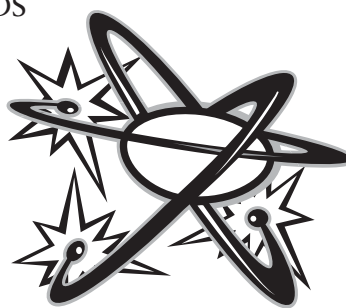
Activity Summary

- In this activity, students will:
- ◆ Discover through laboratory investigations the effect of concentration, surface area, and temperature on the rates of chemical reactions
 - ◆ Read and record pertinent information from MSDS and safety concerns at each station
 - ◆ Complete **Essential Skills** Matching Worksheet



Prior Knowledge

- **Essential Skills** and practice identifying tasks associated with each
- Reading and obtaining information from MSDS
- Safety precautions (e.g., Personal protective equipment)
- Definition of rate of chemical reaction
- Definition of effervescent



Teaching Planning Notes

- Review assignment including prior knowledge required and assessment tools
- Review MSD sheets and laboratory procedures to become familiar with potential safety concerns and to alert students to specific safety concerns before they conduct their investigations.
- Make clear the expectations for cleanup of the work area and the proper disposal of materials.
- Provide a MSDS for hydrochloric acid at station 1 and 2
- Explain roles of Scientist and Recorder for each station. The role of the Scientist is to perform the experiment. The role of the Recorder is to record the observations. The students will switch roles after each station.
- Assign each group a different station to start with and rotate through each one (or do a station/lesson).
- For Station #3, MSDS is not required. On a piece of paper write the following instructions for the students to read: **Chemical safety glasses are required for this station. All ingredients at this station are safe and can be disposed of down the sink. Do not consume the Alka-Seltzer tablet.**
- Provide drawings of each activity on the blackboard for the visual learners.

Note 1: These activities could be completed over three consecutive classes.

Assessment of Student Achievement

Task	Tool / Type
Safety Comes First Worksheet	How Do You Rate? Challenge #1 Worksheet and Assessment Tool (Formative)
How Do You Rate Lab Worksheet	How Do You Rate? Challenge #2 - Lab Worksheets #1, 2 and 3 and Assessment Tool (Formative)
Essential Skills Worksheet	How Do You Rate? Essential Skills Matching Worksheet (Formative)

FOCUS ON LEARNING

Essential Skills:

Reading Text

Conducting Lab

Document Use

Observation Chart

Writing

Completing Lab Worksheets

Essential Skills Matching Worksheet

Oral Communication

Conducting Lab

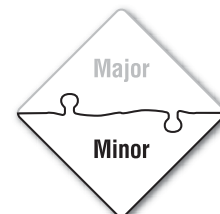
Thinking Skills

Conducting Lab

Essential Skills Matching Worksheet

Working with Others

Conducting Lab



Activity and Assessment Materials

- Rates of Chemical Reactions Assignment Sheet
- Challenge #1: Safety Comes First Worksheet
- Challenge #2: Lab Worksheets #1, 2 and 3 (1 per station)
- Challenge #1 and #2: Answer Key
- Assignment Checklist
- **Essential Skills** Matching Worksheet

Curriculum Linkages For Ontario Educators

Essential Skills truly are everywhere and as teachers we are always teaching students the **Essential Skills!** As subject teachers and specialists, we know that many of the curriculum expectations we are accountable to teach and assess, also address the **Essential Skills** and while the linkages are not always readily apparent, the linkages exist nonetheless.

While this activity connects to a variety of courses, it is most closely aligned to the following course(s):

- Locally Developed Compulsory Credit Course, Grade 10 Science, SNC 2L
- Grade 10 Science Applied, SNC 2P

To assist you, the teacher, in making more transparent linkages, we have identified the following curriculum linkages for this activity.

Locally Developed Compulsory Credit Course, Grade 10 Science, SNC 2L

Coded Overall Expectations	Coded Specific Expectations
CIMV.01 - understand how chemicals in common household and workplace materials interact;	CIM1.04 - identify the factors that alter the rate of physical processes and chemical reactions;
CIMV.02 - investigate the types and rates of interactions between commonly used materials through laboratory activities;	CIM2.04 - conduct experiments to determine the factors affecting rates of chemical reactions and physical processes;

Coded Expectations, Science, Applied, SNC 2P

Coded Overall Expectations	Coded Specific Expectations
CHV.01P - demonstrate an understanding of chemical reactions and the symbolic systems used to describe them;	CH1.04P - describe qualitatively, using their observations, how factors such as heat, concentration, light, and surface area can affect rates of chemical reactions;
CHV.02P - investigate chemical reactions encountered in everyday life and their practical applications;	CH2.01P - through investigations and applications of basic concepts select and use appropriate apparatus, and apply WHMIS safety procedures for the handling, storage, disposal, and recycling of laboratory materials (e.g., wear safety goggles and aprons; use proper techniques to handle, dispose of, and recycle acids, bases, and heavy metal ions; describe procedures to be followed in an emergency); hydrochloric acid and extract the sodium chloride produced);
	CH2.08P - conduct experiments to determine the factors that affect the rate of a chemical reaction (e.g., temperature, surface area of a solid, concentration of a solution)

How Do You Rate?

Imagine that you are the only Canadian contestant in a new episode of Survivor. Your challenge is to build a fire. To get the fire started, you would have more success if you used smaller dry pieces of wood. You could also fan the fire to make it burn more quickly. Why do you think these strategies work? What factors determine how fast a chemical reaction occurs? In these laboratory activities, you will discover factors that affect the rates of chemical reactions.

Challenge #1: Safety Comes First

Reading, Writing, and Document Use are three important **Essential Skills** you will continue to master when you answer the following questions.

Read the MSDS on hydrochloric acid and answer the following questions before starting the laboratory activities. Have the teacher check your answers and sign your paper. Everyone in your group must complete this section before proceeding to your assigned station.

- a) Read Section VII (Spill or Leak Procedures) and describe the steps that must be taken if there is a spill of hydrochloric acid.

- b) Read Section VII (Spill or Leak Procedures) and describe the guidelines for disposing of hydrochloric acid.

- c) Read Section VIII (Special Protection Information) and Section IX (Special Precautions) on the MSDS for hydrochloric acid. List the Personal Protective Equipment you require before starting the lab:

Teacher's signature: _____

How Do You Rate? Challenge #2: Lab Worksheet #1

Station One: Let's Concentrate At This Station!

Date of Investigation: _____

Name of Scientist: _____

Name of Recorder: _____

Purpose: The purpose of this lab investigation is to observe how the change in concentration of hydrochloric acid changes the rate at which chalk reacts.

Hypothesis: If the concentration of hydrochloric acid increases then the rate at which chalk reacts will (increase or decrease).

Materials:

- Safety glasses, aprons and rubber gloves
- Three 100 mL beakers **labeled** with various concentrations of diluted hydrochloric acid
 - Beaker A = 1.0 M $\text{HCl}_{(\text{aq})}$ (approximately 3.0% $\text{HCl}_{(\text{aq})}$)
 - Beaker B = 0.1 M $\text{HCl}_{(\text{aq})}$ (approximately 0.3% $\text{HCl}_{(\text{aq})}$)
 - Beaker C = 0.01 M $\text{HCl}_{(\text{aq})}$ (approximately 0.03% $\text{HCl}_{(\text{aq})}$)
- Three small 50 mL beakers
- One bottle of distilled water
- Disposal container
- MSDS on hydrochloric acid
- Equal pieces of chalk (approx. 2 cm)
- One Stop Watch

Procedure:

1. First read ALL of the procedures before you begin.
2. Place a 2 cm piece of chalk into a small beaker.
3. Add **Acid A** carefully to the 10 mL line to the beaker labeled A.
4. Start the stopwatch.
5. Stop the stopwatch when no more bubbles are produced.
6. Record the time of the reaction (in seconds) in the Observation Chart on the following page.
7. Pour the contents of this beaker into the waste container.
8. Repeat Steps 2 to 7 with Acid B in the next beaker labeled B.
9. Repeat Steps 2 to 7 with Acid C in the next beaker labeled C.
10. Clean up your station. Complete the checklist below before proceeding to the next station.
 - Rinse all beakers with a little distilled water.
 - Wash the counter space.
 - Wash your hands.

How Do You Rate?

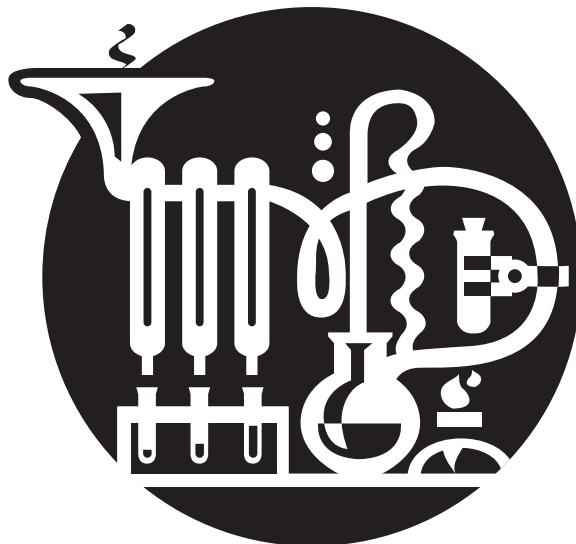
Observation Chart

BEAKER	CONCENTRATION OF HYDROCHLORIC ACID	TIME OF REACTION IN SECONDS (S)
A	3.0% HCl _(aq)	
B	0.3% HCl _(aq)	
C	0.03% HCl _(aq)	

Conclusion:

1. Which beaker had the reaction that lasted the longest time? _____
2. Which beaker had the reaction that lasted the shortest time? _____
3. Which one of the three beakers had the strongest concentration of hydrochloric acid (HCl_(aq))? _____
4. Write a statement to describe how the rate of a reaction is affected by changing the concentration of a substance. _____

5. Was your hypothesis correct? yes no
6. Remember to switch roles at the next station.



How Do You Rate? Challenge #3: Lab Worksheet #2

Station Two: Let's Spread Out At This Station!

Date of Investigation: _____

Name of Scientist: _____

Name of Recorder: _____

Purpose: The purpose of this lab investigation is to observe how the change in surface area of a piece of chalk changes the rate at which it reacts.

Hypothesis: If the surface area of the chalk is smaller then the rate at which chalk reacts will (increase or decrease).

Materials:

- | | |
|---|--|
| <input type="checkbox"/> Safety glasses, aprons and gloves | <input type="checkbox"/> MSDS on hydrochloric acid |
| <input type="checkbox"/> One 100 mL beaker labeled with 0.1 M HCl _(aq) | <input type="checkbox"/> One bottle of distilled water |
| <input type="checkbox"/> Two small 50 mL beakers | <input type="checkbox"/> One stopwatch |
| • Label beaker one for the uncrushed chalk | <input type="checkbox"/> One mortar and pestle |
| • Label beaker two for the crushed chalk | <input type="checkbox"/> Disposal container |
| <input type="checkbox"/> Two equal pieces of chalk (approx. 2 cm) | <input type="checkbox"/> Spoon |

Procedure:

1. First read ALL of the procedure before you begin.
2. Place a 2 cm piece of chalk into the small beaker labeled **one**.
3. Add hydrochloric acid (HCl_(aq)) carefully to the 10 mL line on the beaker.
4. Start the stopwatch.
5. Stop the stopwatch when no more bubbles are produced.
6. Record the time of the reaction (in seconds) in the Observation Chart on the following page.
7. Pour the contents of this beaker into the waste container.
8. Crush the second piece of chalk using the mortar and pestle.
9. Using a spoon, add all of the crushed chalk into the beaker labeled **two**.
10. Add hydrochloric acid (HCl_(aq)) carefully to the 10 mL line on the beaker.

How Do You Rate?

11. Start the stopwatch.
12. Stop the stopwatch when no more bubbles are produced.
13. Record the time of the reaction (in seconds) in the Observation Chart below.
14. Pour the contents of this beaker into the waste container.
15. Clean up your station. Complete the checklist below before proceeding to the next station.
 - Rinse all beakers with a little distilled water.
 - Wash the counter space.
 - Wash your hands.



Observation Chart

BEAKER	SURFACE AREA	TIME OF REACTION IN SECONDS (s)
One	Uncrushed chalk	
Two	Crushed chalk	

Conclusion:

1. a) Which beaker contained chalk with the greatest surface area? _____
 b) Why? _____
2. Which beaker had the reaction that lasted the shortest time? _____
3. Write a statement to describe how the rate of a reaction is affected by changing the surface area of a substance. _____

4. Was your hypothesis correct? Yes No
5. Remember to switch roles at the next station.

How Do You Rate? Challenge #4: Lab Worksheet #3

Station Three: This Is A Cool Station!

Date of Investigation: _____

Name of Scientist: _____

Name of Recorder: _____

Purpose: The purpose of this lab investigation is to observe how changing the temperature of water will change the rate at which an Alka-Seltzer tablet will react.

Hypothesis: If the temperature of the water is higher then the rate at which an Alka-Seltzer tablet reacts will (increase or decrease).

Materials:

- Safety glasses and aprons
- Three large beakers containing water at different temperatures
 - Label beaker **one** for the cold water
 - Label beaker **two** for room temperature water
 - Label beaker **three** for warm water
- Three equal pieces of Alka-Seltzer (or other effervescent tablet)
- One bottle of distilled water
- One stopwatch
- One thermometer
- Spoon

Procedure:

1. First read ALL of the procedure before you begin.
2. Place one piece of effervescent tablet into the small beaker labeled **one**.
3. Take the temperature of the cold water and record the observation in the Observation Table below.
4. Add cold water carefully to the 10 mL line of **beaker one**.
5. Start the stopwatch.
6. Stop the stopwatch when no more bubbles are produced.
7. Record the time of the reaction (in seconds) in the Observation Table on the following page.
8. Pour the contents of this beaker down the sink.

How Do You Rate?

9. Repeat steps 2 to 8 using room temperature water (**beaker two**).
10. Repeat steps 2 to 8 using warm water (**beaker three**).
11. Clean up your station. Complete the checklist below before proceeding to the next station.
 - Rinse all beakers with a little distilled water.
 - Wash the counter space.
 - Wash your hands.



Observation Chart

BEAKER	TEMPERATURE OF THE WATER	ACTUAL TEMPERATURE OF THE WATER (°C)	TIME OF REACTION IN SECONDS (S)
One	Cold		
Two	Room Temperature		
Three	Warm		

Conclusion:

1. Which beaker contained the reaction that lasted the longest time? _____
2. Which beaker had the reaction that lasted the shortest time? _____
3. Write a statement to describe how the rate of a reaction is affected by changing the temperature of a substance. _____

4. Was your hypothesis correct? Yes No
5. Remember to switch roles at the next station.

How Do You Rate? Answer Key

Challenge #1: Safety Comes First

Read the MSDS on hydrochloric acid and answer the following questions before starting the laboratory activities. Have the teacher check your answers and sign your paper. Everyone in your group must complete this section before proceeding to your assigned station.

- a) Read Section VII (Spill or Leak Procedures) and describe the steps that must be taken if there is a spill of hydrochloric acid.

Carefully neutralize the hydrochloric acid with sodium bicarbonate and flush down the drain with lots of water.

- b) Read Section VII (Spill or Leak Procedures) and describe the guidelines for disposing of hydrochloric acid.

Carefully neutralize with sodium bicarbonate, soda ash, or lime and flush down the drain with lots of water.

- c) Read Section VIII (Special Protection Information) and Section IX (Special Precautions) on the MSDS for hydrochloric acid. List the Personal Protective Equipment you require before starting the lab:

Chemical safety glasses

Rubber gloves

Smock or apron

Challenge #2: Lab Worksheet #1

(Station One: Let's Concentrate At This Station!)

Hypothesis: If the concentration of hydrochloric acid increases then the rate at which chalk reacts will *increase*.

Observation Chart: *students should observe that the reaction is faster when the concentration of hydrochloric acid is stronger. (3.0 %)*

Conclusion:

1. Which beaker had the reaction that lasted the longest? C
2. Which beaker had the reaction that lasted the shortest time? A
3. Which one of the three beakers had the strongest concentration of hydrochloric acid ($\text{HCl}_{(\text{aq})}$)? A
4. Write a statement to describe how the rate of a reaction is affected by changing the concentration of a substance.

The rate of a chemical reaction is faster when the concentration of a chemical increases.

How Do You Rate?

Challenge #3: Lab Worksheet #2

(Station Two: Let's Spread Out At This Station!)

Hypothesis: If the surface area of the chalk is smaller then the rate at which chalk reacts will decrease.

Observation Chart: *Students will observe that the crushed chalk will react faster.*

Conclusion:

1. a) Which beaker contained chalk with the greatest surface area? Two
b) Why? *Because the crushed chalk is in smaller pieces*
2. Which beaker had the reaction that lasted the shortest time? Two
3. Write a statement to describe how the rate of a reaction is affected by changing the surface area of a substance.
The greater the surface area (smaller pieces) the greater the rate of the chemical reaction.

Challenge #4: Lab Worksheet #3

(Station Three: This Is A Cool Station!)

Hypothesis: If the temperature of the water is higher then the rate at which an Alka-Seltzer tablet reacts will increase.

Observation Chart: *Students will observe that the beaker containing the warm water will react the fastest. The slowest reaction occurs in the cold water.*

Conclusion:

1. Which beaker contained the reaction that lasted the longest time? One
2. Which beaker contained the reaction that lasted the shortest time? Three
3. Write a statement to describe how the rate of a reaction is affected by changing the temperature of a substance.
When the temperature of a substance increases, the rate at which it reacts also increases.

How Do You Rate? Checklist

ACTIVITY	DATE DUE	COMPLETED
Challenge #1		<input type="checkbox"/>
Challenge #2: Lab Worksheet #1		<input type="checkbox"/>
Challenge #3: Lab Worksheet #2		<input type="checkbox"/>
Challenge #4: Lab Worksheet #3		<input type="checkbox"/>
<i>Essential Skills</i> Matching Worksheet		<input type="checkbox"/>

Essential Skills Matching Worksheet

Throughout the three lab activities, you performed many tasks. Read the tasks stated below and match an **Essential Skill** that best suits the task. There are two blank rows for you to complete. Think about two other tasks you carried out in your lab activities and match them to an **Essential Skill**.

TASK PERFORMED	MATCH AN Essential Skill TO THE TASK PERFORMED		
	Reading Text Document Use Numeracy	Oral Communication Working with Others Thinking Skills	Writing Computer Use Continuous Learning
Interpreting information from MSDS			
Measuring the temperature of the water			
Sharing role of Scientist and Recorder with your partner			
Following the instructions in the laboratory procedure			
Recording observations in the data table.			