Name: _____ Period:_____ Date:_____

# Measuring Reaction Rates Guided Notes – Student Edition

**Reaction Rate Investigations**

There are three variables which must be considered when investigating the rate of reaction:

- The _____ variable – the factor which is being _____. In this case, this will be one of the _____ which affect the rate of reaction, e.g. Temperature, surface area, concentration, nature of the reactants and presence of a catalyst. This factor will state a range of values to be tested.
- The _____ variable – the factor which is being _____ to obtain some data, in this case, the reaction rate.
- The _____– all other variables which must be kept _____ to ensure that the results are reliable.

**Practice Problem:**

For each of the following hypotheses, identify the independent, dependent and controlled variables:

1. When the surface area of zinc metal is increased, the reaction rate (hydrogen gas production) will also increase.

   **Independent Variable:**

   **Dependent Variable:**

   **Controlled Variables:**

# Measuring Reaction Rates Guided Notes – Student Edition

2. As the temperature of the acid increases, the time taken for the precipitate to form also increases.

   **Independent Variable:**

   **Dependent Variable:**

   **Controlled Variables:**

3. When the concentration of hydrochloric acid is increased, the rate of gas production also increases.

   **Independent Variable:**

   **Dependent Variable:**

   **Controlled Variables:**

Name: _____ Period:_____ Date:_____

# Measuring Reaction Rates Guided Notes – Student Edition

**Methods to Measure the Reaction Rate**

The method must describe how the independent variable will be _____ and how the dependent variable will be _____. The reaction rate can be measured in two ways:

- How quickly the _____ are used up
- How quickly the _____ form

The rate of reaction is easy to determine if the reaction involves a _____or the formation of a _____.

**Reactions which involve a change in color**

The rate of reaction is monitored by determining how quickly the color changes.

**Example: The iodine clock reaction**

The iodine clock reaction is the oxidation of iodide ions by hydrogen peroxide. In this reaction, the two clear solutions, one containing iodine (known as solution A) and the other containing starch (known as solution B) react to give a rapid, blue-black color change.

**Practice Problem:**

For the above example experiment, identify the three types of variables and write a method to describe how to measure the reaction rate when the temperature of one of the solutions is changed.

**Independent Variable:**

**Dependent Variable:**

**Controlled Variables:**

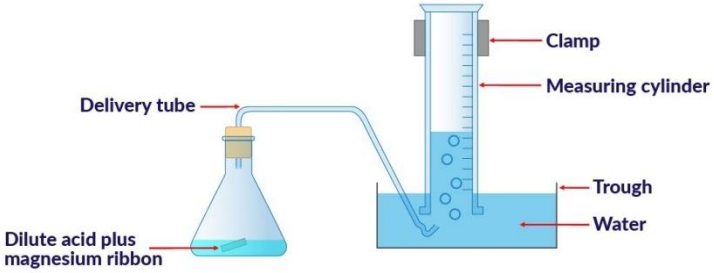
Name: _____ Period:_____ Date:_____

# Measuring Reaction Rates Guided Notes – Student Edition

**Method:**

**Reactions where a gas is produced**

The rate of reaction can be determined by measuring how much gas is produced after a certain time interval (see the setup below).


**Example: Hydrogen Gas**

The equation for the reaction between zinc metal and dilute hydrochloric acid is:

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$$

The hydrogen gas produced can be collected, and its volume measured at specific time intervals. A lit splint can be used to confirm the presence of hydrogen as it will make a 'pop' sound when the split is placed in near the hydrogen.

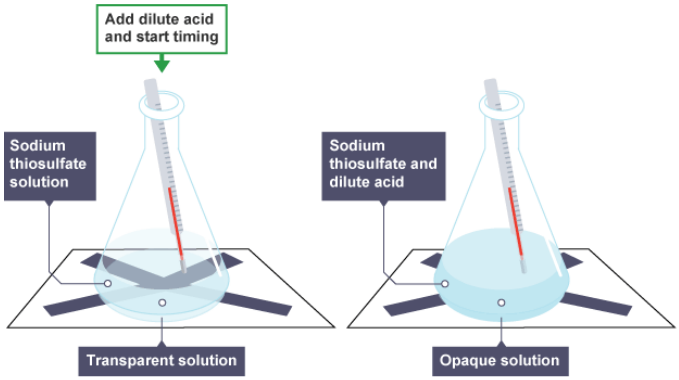
**Precipitate reactions:**

In reactions where a precipitate is formed _____can be used as a measure of the reaction rate. These reactions require a clear understanding of where the _____ for the reaction is. For example, when sodium thiosulphate reacts with an acid, a cloudy yellow sulfur precipitate is formed. The endpoint for this reaction is when the _____ on the under sheet of paper is no longer able to be seen. The reaction is as follows:

$$Na_2S_2O_{3(aq)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + SO_{2(aq)} + H_2O_{(l)} + S_{(s)}$$

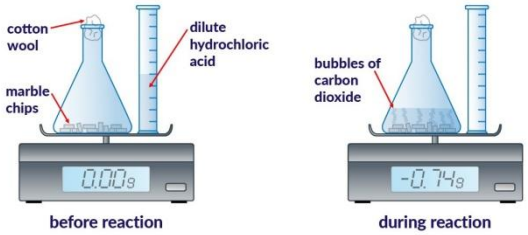
Name: _____ Period:_____ Date:_____

# Measuring Reaction Rates Guided Notes – Student Edition




**Changes in mass:**

The rate of a reaction that produces a gas can also be measured by calculating the _____ as the gas is formed and escapes from the reaction flask. This method can be used for reactions that produce _____ or _____, but are not very accurate for reactions that give off hydrogen because the mass is _____for accuracy. Measuring changes in mass may also be suitable for other types of reactions such as dissolving of _____ substances.




**Delayed Reactions**

Some chemicals will have a _____ reaction if they have a _____ over their surface. Many metals upon contact with air produce an _____, which slows down the reaction. This can be overcome by sanding the metal before using it.

**Practice Problem:**

Hydrochloric acid and calcium carbonate (marble chip) react according to the following equation:

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

Describe in detail, how the rate for this reaction can be increased by changing the concentration of the acid. You must include:

Name: _____ Period:_____ Date:_____

# Measuring Reaction Rates Guided Notes – Student Edition

- The independent variable and how it will be changed
- The dependent variable and how it will be measured
- Any relevant controlled variables and how they will be kept the same

**Answer:**

- **Independent variable:**

- **Dependent variable:**

- **Controlled variables:**

- **Method:**

Name: _____ Period:_____ Date:_____

# Measuring Reaction Rates Guided Notes – Student Edition

## Data Processing

Data collected from an investigation is typically displayed as both a _____ and a _____.

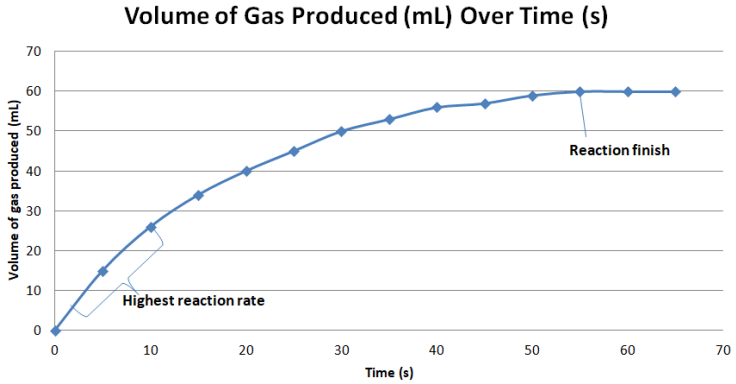
### Example: Rate of Hydrogen gas Production

When a magnesium ribbon dissolves in an acid, hydrogen gas is produced. The equation for this reaction is as follows:

$$Mg_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$$

The results from this experiment are displayed below:

| Time from start (s) | 0 | 5 | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Volume of gas collected (mL) | 0 | 15 | 26 | 34 | 40 | 45 | 50 | 53 | 56 | 57 | 59 | 60 | 60 | 60 |




A typical rate of reaction graph:

- Begins rapidly with a _____.
- Slows down as time progresses, the slope of the graph becomes _____as the reaction progresses. This is due to the concentration of the reactants _____.
- Stops after a particular time. This is seen as the slope _____, indicating that one or both reactants have been used up.

### Calculating the Rate of Reaction from a Graph

- The gradient of the graph is equal to the rate of reaction (_____) at a specific point in time (_____). Therefore, rate of reaction can be calculated using the equation:

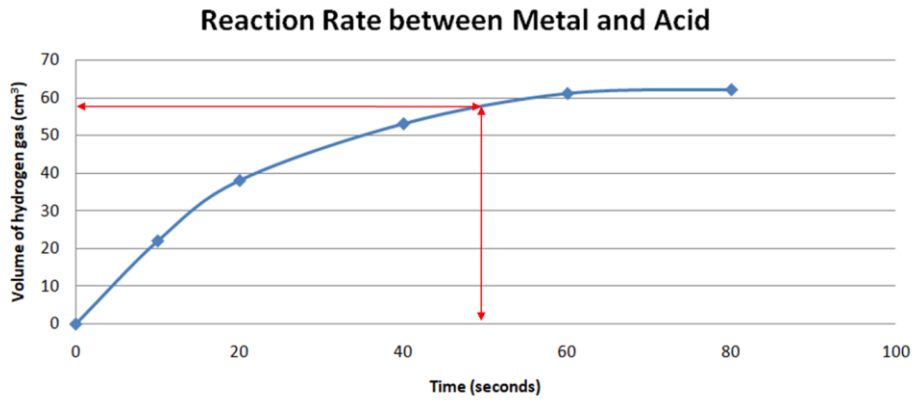
Name: _____ Period:_____ Date:_____

# Measuring Reaction Rates Guided Notes – Student Edition

## Rate of reaction = y/x

**For Example:**

The graph below shows the reaction rate of a metal with acid.




Reaction rate at 50 seconds can be calculated by:

**Practice Problem**

The volume of carbon dioxide that is produced during the reaction is measured at different times over ten minutes. The results are shown in the table below.

| Time (mins) | The volume of $CO_2$ produced ($cm^3$) |
|---|---|
| 1 | 14 |
| 2 | 26 |
| 3 | 36 |
| 4 | 44 |
| 5 | 50 |
| 6 | 58 |
| 7 | 65 |
| 8 | 70 |
| 9 | 74 |
| 10 | 77 |

Name: _____ Period:_____ Date:_____

# Measuring Reaction Rates Guided Notes – Student Edition

1. Use the data in the table to draw a graph showing the volume of gas that is produced in the reaction, over 10 minutes.

2. At which of the following times is the reaction fastest? (circle one)
   Time = 1 minute; time = 6 minutes or time = 8 minutes.

3. Suggest a reason why the reaction slows down over time.

4. If the experiment was repeated using a more concentrated hydrochloric acid solution:
   a) Would the rate of the reaction increase or decrease from the one shown in the graph?

   b) Give a reason for your answer

   c) Draw a line on the graph to show how you would expect the reaction to proceed with a more concentrated HCl solution.