Rate Law for the Reaction of Magnesium and Hydrochloric Acid

The video below shows magnesium metal added to hydrochloric acid. After the magnesium is added, we can see the progress of the reaction by observing the motion of the piston in the gas-collecting cylinder.

Alt-Text: On the left side of the video, a test tube is being held in place by metal supports. The test tube is tilted so that its top is to the right and the bottom is to the left. There is a rubber stopper in the top of the test tube that is attached to a clear plastic tube that goes to a graduated cylinder with a low friction plunger that can expand if the chemical reaction in the test tube produces gas. On the right side of video is a high precision electronic balance.

When the video starts the electronic balance reads zero. The gloved hands of a student appear and place a small U-shaped piece of metal on the balance which eventually comes to rest at a reading of 0.070 grams.

The student then places the metal inside of the test tube where it is held in place by a magnet on the outside of the test tube. The rubber stopper is again placed in the top of the test tube and then the metal is lowered into the liquid with the magnet. Bubbles form around the metal piece in the liquid and vapor starts to condense on the sides of the test tube above the liquid. At that point the video plays at 8 times normal speed, and the piston in the graduated cylinder which is collecting the gas from the

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1. Write the balanced chemical equation for this reaction.   ● Saved

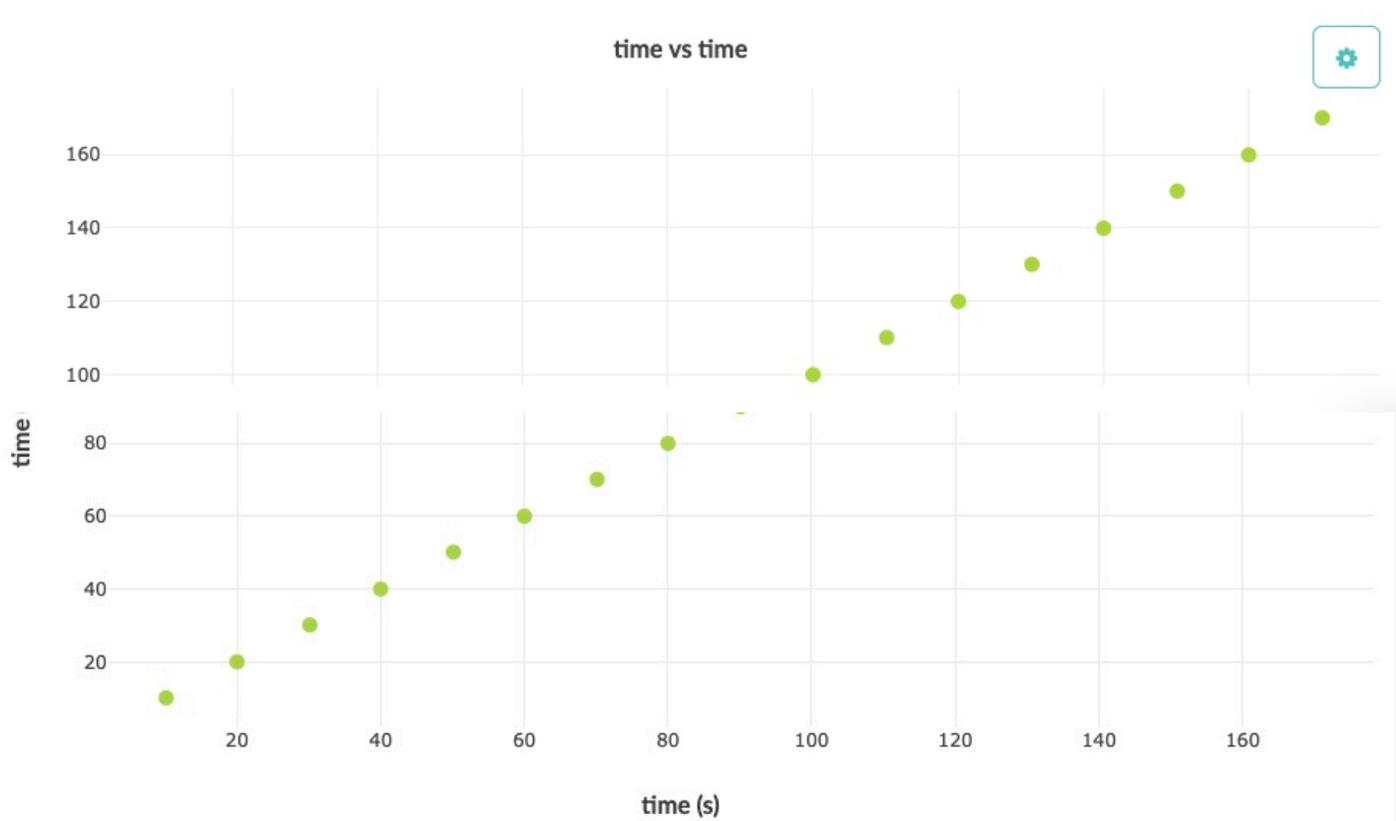| B I U   ≣ ≣ ≣ ≣   🔗 🖼 f_x |
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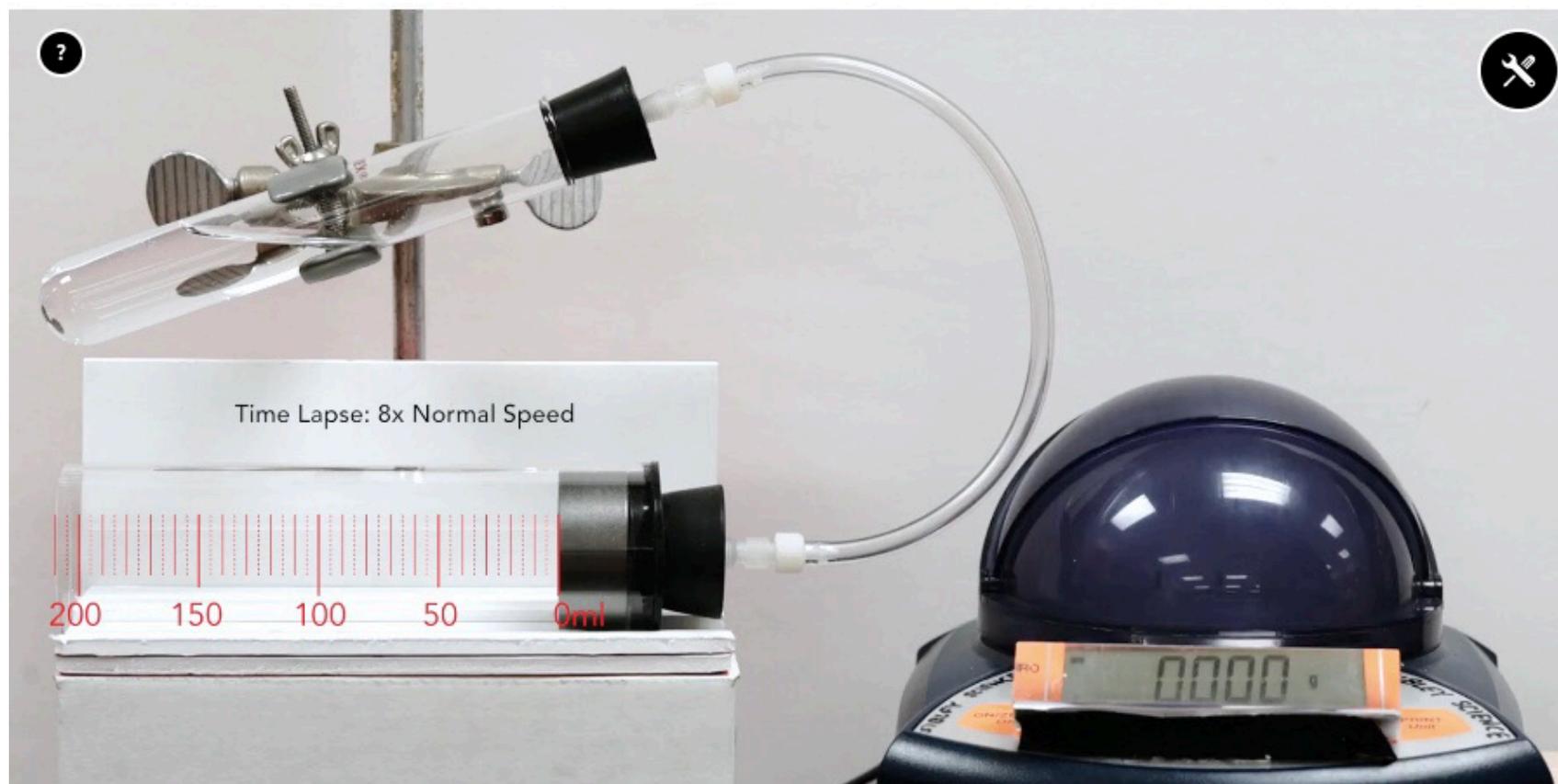
2. Use this table and graph to collect and plot data. Follow the directions below for instructions on how we'll be using this table and graph.

		time		Volume of H2	
	⚙	s	variable	ml	variable
1	⋯	10.13		5	
2	⋯	20		9.6	
3	⋯	30.13		13	
4	⋯	40		16	
5	⋯	50.13		21	
6	⋯	60		24	
7	⋯	70.13		27	
8	⋯	80		32.5	
9	⋯	90.13		38	
10	⋯	100		45	
11	⋯	110.13		51	
12	⋯	120		56	
13	⋯	130.13		59	
14	⋯	140		62	
15	⋯	150.13		64	
16	⋯	160		66	
17	⋯	170.13		66	

time vs time

time vs time

Score: 0 / 2

3. Begin by collecting data to plot the *volume of hydrogen gas produced* as a function of time. You'll have some decisions to make:

- When should you begin measuring time (that is, at what point in the video do you reset the stopwatch to zero?)
- How many data points should you collect?
- At what time should you stop recording data?
- What quantities will you plot on each axis?

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4. Once you have your data collected, plot *volume of H_2 produced* on the vertical axis and *time* on the horizontal axis. Click the *linear regression button at the lower left of the graph to see the equation for the graph.* What do you notice about the slope of the graph?

- What are the units for the slope?
- What is the meaning of the slope?

Answer each of these in the space below.

Hint: *For meaning of slope, try "The slope tells the number of [vertical axis units] the [vertical axis quantity] changes **for every** [horizontal axis units] the [horizontal quantity] changes.*

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5. At what rate is hydrogen gas being produced by this reaction? Explain your reasoning.

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6. Notice that the line on the graph is straight, or nearly straight, until the reaction ends. What does the straightness of the graph tell us about the rate at which the reaction progresses?

Hint: *You can exclude data points from the linear regression by clicking on them on the graph. You may want to click to exclude some data points near the end of the reaction when the magnesium is nearly all consumed.*

◯ The slope is constant, so the rate of the reaction is constant.

◯ The constant slope tells us that the reaction is speeding up.

◯ The slope is constant, showing that the rate of the reaction slowing.

◯ The slope is constant, so the amount of hydrogen gas is not changing.

Score: 0 / 2

[Submit Answer] 2 / 2 submissions remaining

7. Create a new calculated column to convert the *volume of hydrogen gas produced* into *the amount of magnesium that has been consumed* in the reaction.

This animation below shows how to use the calculator to create a calculated column, but does not show what equation you will need to calculate the amount of magnesium consumed. That's your job.

Alt-Text: The animation is a slightly altered example of the standard Data Table used in Pivot Interactives. This table has a left end column numbering from the top down the number of rows, with a blank cell at the top. The middle and right-end columns have 2 customizable cells at the top that combined have the same height as the blank cell in the column to the left. "Time" is the text in the column name cell, and "s" is the text in the unit cell for the middle column, and "V of Hydrogen gas produced" and "mL" is the text in the Column name and unit cells of the right end column respectively. The two Column Name cells also have "three-dot" menus to click on that reveal a list of options.

The three-dot menu of the "V of Hydrogen gas produced" is clicked on and then the "insert column right" option is clicked on. This new column is now on the right end of the table and the text in the Column name is entered as "mol of Hydrogen gas" and the unit cell text is entered as "mol." The three-dot menu of this new column is clicked on and the "change column formula" option is clicked on which reveals a pop-up calculator with a standard number pad, and a box with the titles of the other two columns in the Data Table in a top-down order starting with the "time" column.

The animation demonstrates that a formula can be created for the column by clicking on the title of one of the other existing columns, and then clicks on the division symbol, revealing that mathematical operations can be conducted using a whole other column as opposed to doing these calculations yourself for each individual data point.

	time		V of H2 produce		mol of H2	
	s		mL		units	
1	0		0			
2	10.13		4			
3	20		8.5			
4	30		13			
5	40		16			
6	50		20.5			
7	60		24			
8	70		28			
9	80		32			
10	90		37			

Enter an equation in the calculator that will convert the volume of hydrogen gas to the number of moles of magnesium remaining in the test tube.

Plot this new quantity on the vertical axis of the graph. Use the linear regression tool to find the slope of this line. Describe

Plot this new quantity on the vertical axis of the graph. Use the linear regression tool to find the slope of this line. Describe how you did this, and state what the new graph looks like.

Hint: *Assume 24 liters of gas = 1 mole of gas at this temperature.*

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Score: 0 / 2

8. Create another calculated column showing the amount (in grams) of Mg remaining in the test tube.

Describe the calculation you made, and describe the shape of the graph now.

Hint: *How much magnesium was present at the start of the reaction?*

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Score: 0 / 2

9. Determine the rate at which magnesium is consumed during this reaction.

Hint: *Use the linear regression button to find the slope.*

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Score: 0 / 1

10. Which of these is the best representation of how the rate of the reaction depends on the amount of magnesium remaining in the test tube?

○

rate at which magnesium is consumed (g/s)

amount of magnesium in the test tube (g)

○

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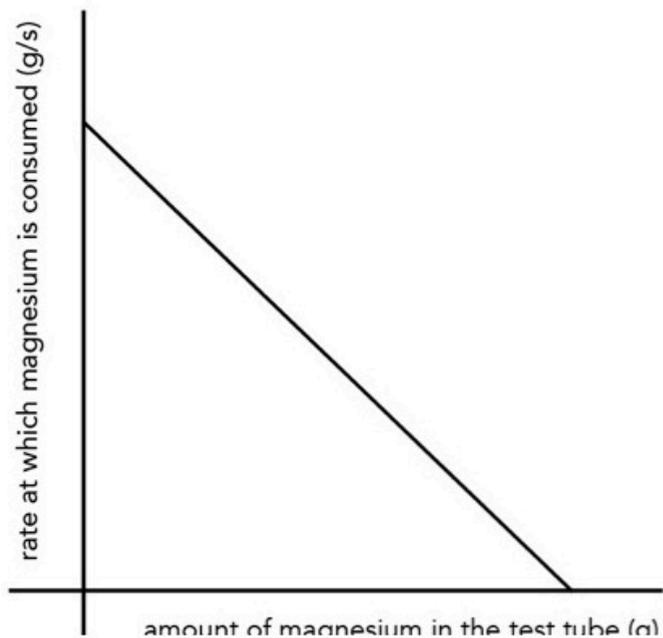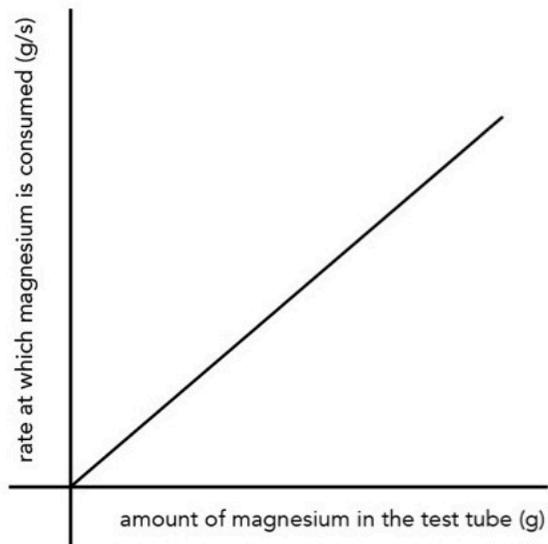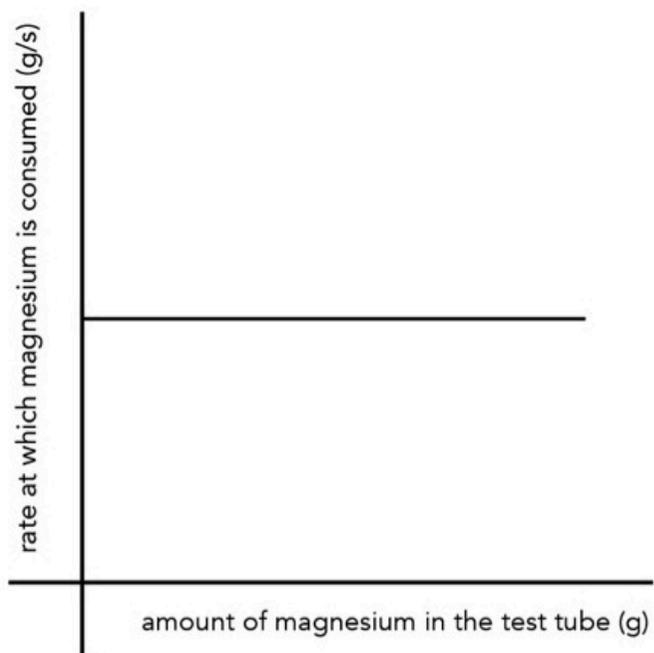
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Submit Answer   2 / 2 submissions remaining

11. Based on your answer, what is the order of the reaction between magnesium and hydrochloric acid, with respect to magnesium?

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Score: 0 / 2