II) Investigating Rate

Monday, September 11, 2017 2:20 PM

Reaction Rate: the speed of a reaction — quantitative data/measure — amount of product formed / time OR amount of reactant used / time

Mathematically, rate = $\frac{\Delta \text{ quantity}}{\Delta \text{ time}}$ What is Δ? "change in" (delta)

https://www.absorblearning.com/chemistry/demo/units/LR1501.html#Introduction

What are some examples of a 'quantity' that can change in a reaction?

- concentration of a solution
- temperature Δ
- volume of reactant used / product formed
- mass of " "
- volume of a gas " "

Therefore, what are some valid units for rate?

$\frac{g}{s}$ $\frac{mg}{s}$ $\frac{mL}{s}$ $\frac{L}{min}$ $\frac{M}{hr}$ $\frac{Kg}{min}$ ← bottom MUST be time

Suppose we observe the following reaction in the lab. What are some quantities we could measure over a period of time in order to obtain a reaction rate?

$Mg_{(s)} + 2HCl_{(aq)} \Rightarrow MgCl_{2(aq)} + H_{2(g)}$ + ΔE (heat)

mass (g) volume (mL)

- mass of Mg lost (g) / unit of time (s)
- volume of H2 gas produced (mL) / time (s)
- mass of H2 gas produced / time (s) (b/c comparing to loss on scale)

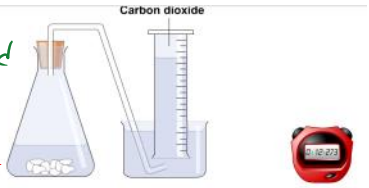


Figure 2. Measuring the volume of gas given off (1).

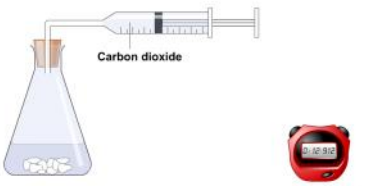
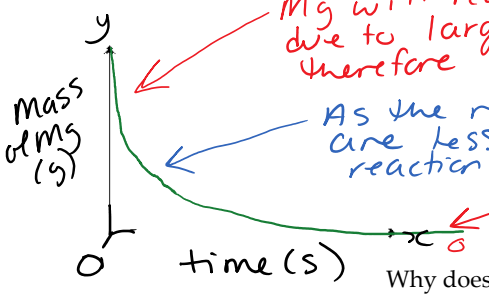


Figure 3. Measuring the volume of gas given off (2).

Figure 4. Measuring the mass of gas given off.

Rate can be measured by measuring the consumption of a reactant, or measuring the production of a product, all the while timing the reaction.

Suppose the rate for the reaction under discussion was determined by measuring the mass loss of the reactant $Mg_{(s)}$ per unit time. Draw a graph to represent this:



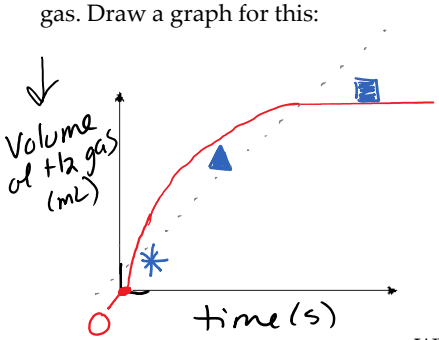
Mg will react very quickly at the start due to large amount of reactant and therefore more effective collisions/s.

As the reactants are used up, there are less effective collisions, so reaction rate slows

rxn stops when all reactants are used up. rxn rate = 0.

Why does the graph have this shape?

Suppose the rate is determined by monitoring the increase in volume of the product H_2 gas. Draw a graph for this:



* H2 (g) is produced very quickly b/c more effective collisions at start of reaction
▲ less H2 (g) formed as the reactants become used up.... less effective collisions occuring
■ reactants have been used up. max volume of H2 (g) has been produced. no more effective collisions

Why does the graph have this shape?

Remember from math that slope = $\frac{\text{rise}}{\text{run}}$ ↑ y-axis → x-axis

What is the rise (y axis) in each of the graphs we've just drawn?
A change in quantity (dep. var.)
What is the run (the x axis) in each?
A change in time (indep. var.)
Therefore, what does the slope of these graphs represent?

$\frac{\text{rise}}{\text{run}} = \frac{\Delta \text{quantity}}{\Delta \text{time}}$ = reaction rate = slope of line!!

Reaction has finished

Therefore, what does the slope of these graphs represent?

$\frac{\text{rise}}{\text{run}} = \frac{\Delta \text{quantity}}{\Delta \text{time}}$ = reaction rate = slope of line!!

What are the units of rate for each of the previous two graphs?

First graph:

Second graph:

Look at the two graphs again. What do you notice about the magnitude of the slope as your reaction proceeds? What does this tell you about reaction rate as a reaction proceeds?

Figure 6. Graph showing the changing rate of a reaction.

https://www.absorblearning.com/chemistry/demo/units/LR1501.html#Graphsandrates

Draw a graph of rate (y axis) vs. time for a reaction:

As reactants get used up, there are less and less collisions between reactant particles, therefore less and less effective collisions, so reaction rate is always decreasing!

AS A REACTION PROCEEDS, THE RATE IS ALWAYS DECREASING.

Assignment 1:

1) For the reaction: $NaHCO_{3(s)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$
Describe three things that you could measure while timing the reaction to calculate a reaction rate. For each, state the quantity being measured and what substance is being measured.

2) For the reaction: $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$
Describe three things that you could measure while timing the reaction to calculate a reaction rate. For each, state the quantity being measured and what substance is being measured.

3) Hebden page 10, question 17

4) For the reaction: $2H_{2(g)} + O_{2(g)} \rightarrow 2H_2O_{(l)}$
Draw a graph for:
a) Mass loss of O_2 per unit time as the reaction proceeds
b) volume gain of H_2O per unit time
c) rate per unit time