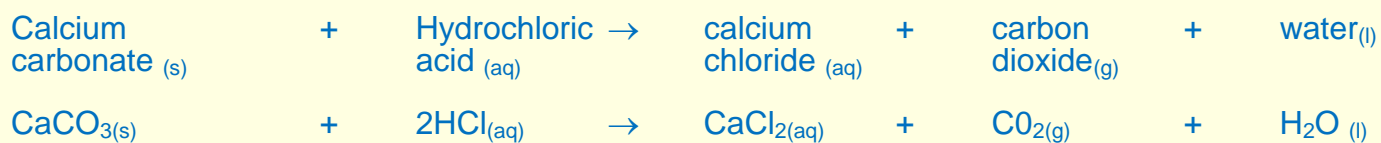


# RATES OF REACTION

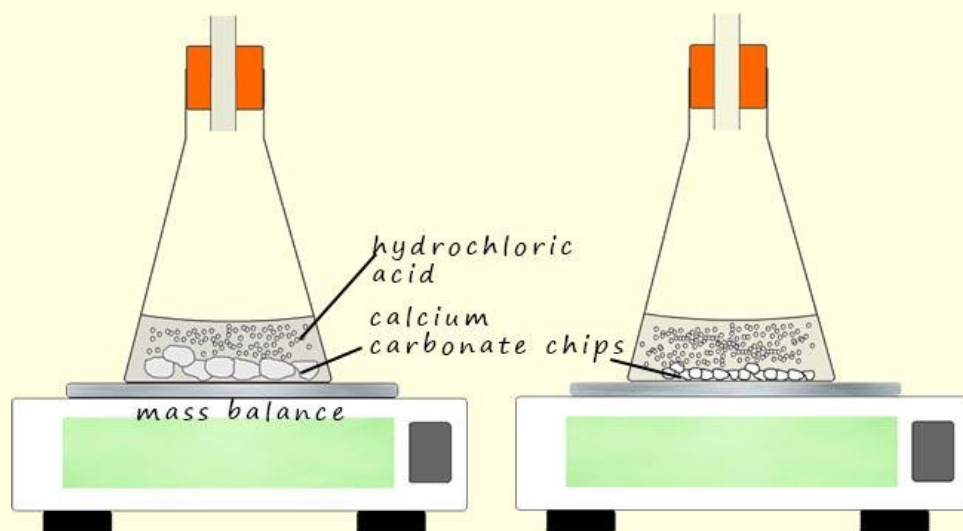
## SURFACE AREA

Answer all the questions below then check your answers

A student was investigating how changing the surface area will affect the rate of a chemical reaction. The reaction he was studying was the reaction of Calcium carbonate reacts with hydrochloric acid:



The rate can be measured using the apparatus shown below:



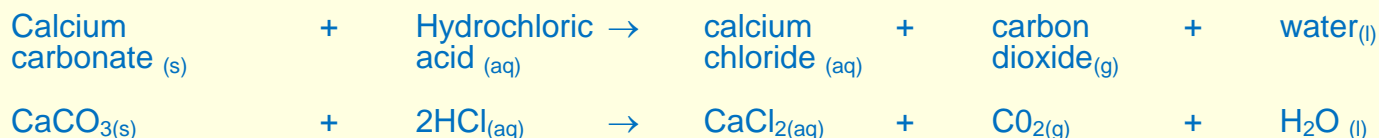
1. How will the student change the surface area of the calcium carbonate?
2. Which has the largest surface area, small chips or large chunks of calcium carbonate?
3. Explain how the student will measure the rate of reaction using the apparatus shown above
  - a. In this investigation what is :
    - i. The independent variable?
    - ii. The dependent variable?
4. To make the experiment fair what variables should be controlled?
5. Another student was also investigating how reaction rate is affected by surface area. However this time she decided to measure the volume of carbon dioxide gas produced over a period of time. She carried out 2 experiments. One using 5g of crushed powdered calcium carbonate and another using 5g of small pieces of calcium carbonate. Her results are shown below:

| Time/s | Volume of carbon dioxide produced/ml |       |
|--------|--------------------------------------|-------|
|        | Set 1                                | Set 2 |
| 0      | 0                                    | 0     |
| 5      | 20                                   | 30    |
| 10     | 40                                   | 17    |
| 20     | 60                                   | 33    |
| 30     | 68                                   | 47    |
| 40     | 72                                   | 58    |
| 50     | 72                                   | 66    |
| 60     | 72                                   | 70    |
| 70     | 72                                   | 72    |
| 80     | 72                                   | 72    |
| 90     | 72                                   | 72    |

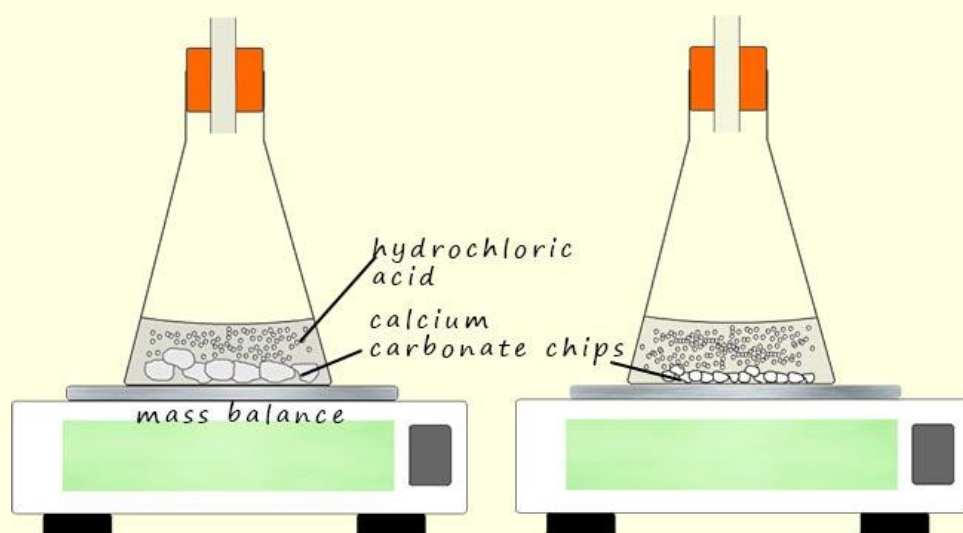
- a. Draw a labelled diagram of the apparatus she could use to carry out her investigation.
- a Plot a graph of volume of carbon dioxide produced against the time in seconds. Plot the set 1 and set 2 results above onto this graph.
- b Which set of results is from the crushed calcium carbonate?
- c What was the maximum volume of gas produced?
- d For the crushed calcium carbonate what was the average rate of production of carbon dioxide gas over:
- i The first 20 s    ii The NEXT 20 s.    iii The next 20 s
- ii Explain why the rate of reaction slows down with time.
- e Why do the crushed and solid calcium carbonate both produce the same amount of carbon dioxide at the end of the experiment?
- f How long did it take for the reaction to finish?
- g Draw a third line on the graph paper to show the graph that would be produced if middle sized particles of calcium carbonate were used, these particles are smaller than the lumps but larger than the powdered particles.

## Answers

A student was investigating how changing the surface area will affect the rate of a chemical reaction. The reaction he was studying was the reaction of Calcium carbonate reacts with hydrochloric acid:



The rate can be measured using the apparatus shown below:



Answer all the questions below.

1. How will the student change the surface area of the calcium carbonate?  
*Use a mortar and pestle to grind up the chips to the required size*
2. Which has the largest surface area, small chips or large chunks of calcium carbonate?  
*Smaller the chips the larger the surface area*
3. Explain how the student will measure the rate of reaction using the apparatus shown above.  
*Measure the change in mass from the balance every 20 or 30 seconds. The larger the change in mass over the given time the more carbon dioxide gas is released and the faster the reaction.*

a. In this investigation what is :

i. the independent variable? *Surface area of calcium carbonate*

ii. the dependent variable? *Change in mass*

4. To make the experiment fair what variables should be controlled?

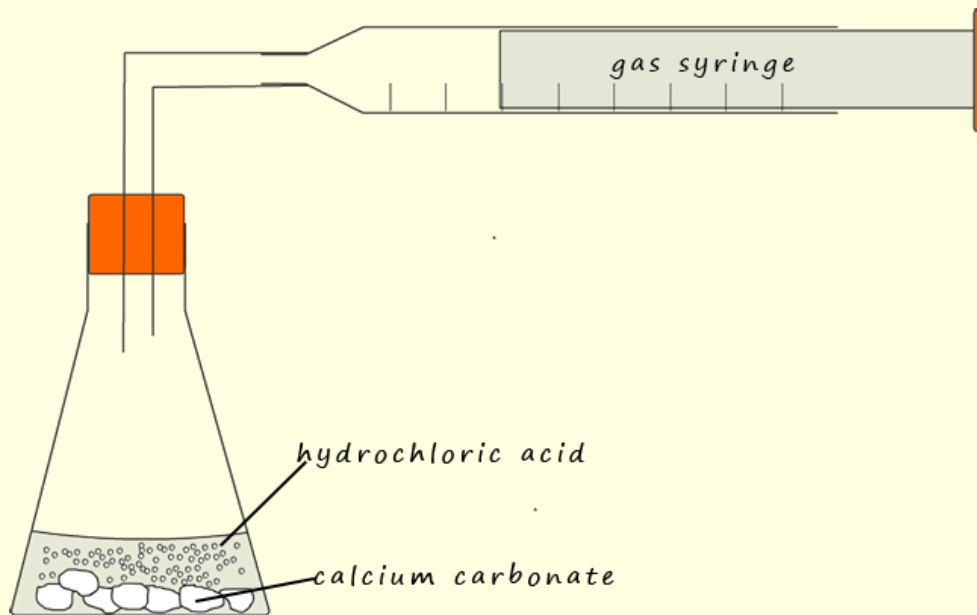
*Control variable could include:*

- *Keep same acid concentration in both experiments.*
- *Same acid temperature in both experiments.*
- *Same mass of calcium carbonate in both experiments.*

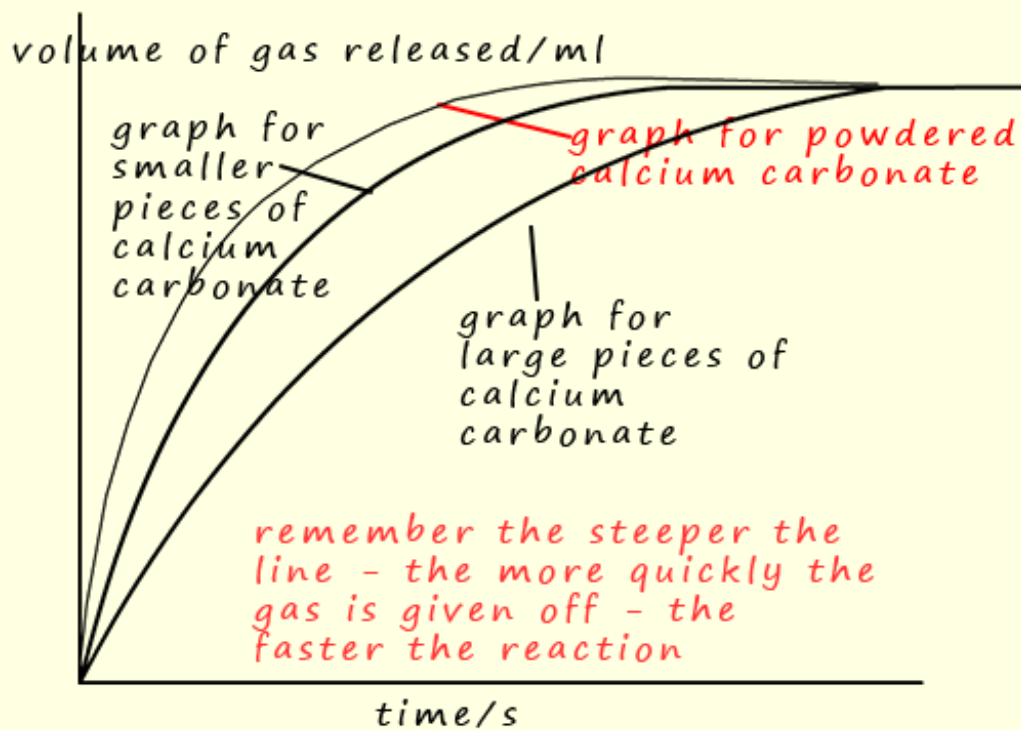
5. Another student was also investigating how reaction rate is affected by surface area. However this time she decided to measure the volume of carbon dioxide gas produced over a period of time. She carried out 2 experiments. One using 5g of crushed powdered calcium carbonate and another using 5g of small pieces of calcium carbonate. Her results are shown below:

| Time/s | Volume of carbon dioxide produced/ml |       |
|--------|--------------------------------------|-------|
|        | Set 1                                | Set 2 |
| 0      | 0                                    | 0     |
| 5      | 20                                   | 30    |
| 10     | 40                                   | 17    |
| 20     | 60                                   | 33    |
| 30     | 68                                   | 47    |
| 40     | 72                                   | 58    |
| 50     | 72                                   | 66    |
| 60     | 72                                   | 70    |
| 70     | 72                                   | 72    |
| 80     | 72                                   | 72    |
| 90     | 72                                   | 72    |

a. Draw a labelled diagram of the apparatus she could use to carry out her investigation.



- a Plot a graph of volume of carbon dioxide produced against the time in seconds. Plot the set 1 and set 2 results above onto this graph.



b Which set of results is from the crushed calcium carbonate? Explain how you know this? The larger the surface area of the calcium carbonate, that is the smaller the pieces the steeper will be the line on the graph. The line for powdered calcium carbonate will be very steep as the reaction will be rapid.

c What was the maximum volume of gas produced? 72ml

d For the crushed calcium carbonate what was the average rate of production of carbon dioxide gas over:

i The first 20 s    ii The NEXT 20 s.    iii The next 20 s

i. crushed calcium carbonate released 60ml over 20s,

so average rate = volume of gas/time taken

$$33/20 = 1.65\text{ml/s} \quad (1.65\text{ml per second})$$

ii next 20 seconds, volume released is 24ml, time is 20 seconds

so average rate = volume of gas/time taken

$$25/20 = 1.25\text{ml/s} \quad (1.25\text{ml per second})$$

iii next 20 seconds, volume released is 12ml, time is 20 seconds

so average rate = volume of gas/time taken

$$12/20 = 0.6\text{ml/s} \quad (0.6\text{ml per second})$$

ii Explain why the rate of reaction slows down with time.

The reactants are being used so the concentration of them is slowly decreasing, so less successful collisions so a slower rate of reaction.

e Why do the crushed and solid calcium carbonate both produce the same amount of carbon dioxide at the end of the experiment? Used 5g of both at the start of the reaction. The acid is in excess so the limiting factor is the calcium carbonate, used the same number of moles or mass of this in both experiments.

f How long did it take for the reaction to finish?

From your graph measure from when the curve begins to go flat for each of the crushed and powdered calcium carbonate.

g Draw a third line on the graph paper to show the graph that would be produced if middle sized particles of calcium carbonate were used, these particles are smaller than the lumps but larger than the powdered particles. Line on graph would be in between the other two lines, remember the steepest of the line represents the rate of reaction and rate increases as the particles get smaller, that is their surface area increases.