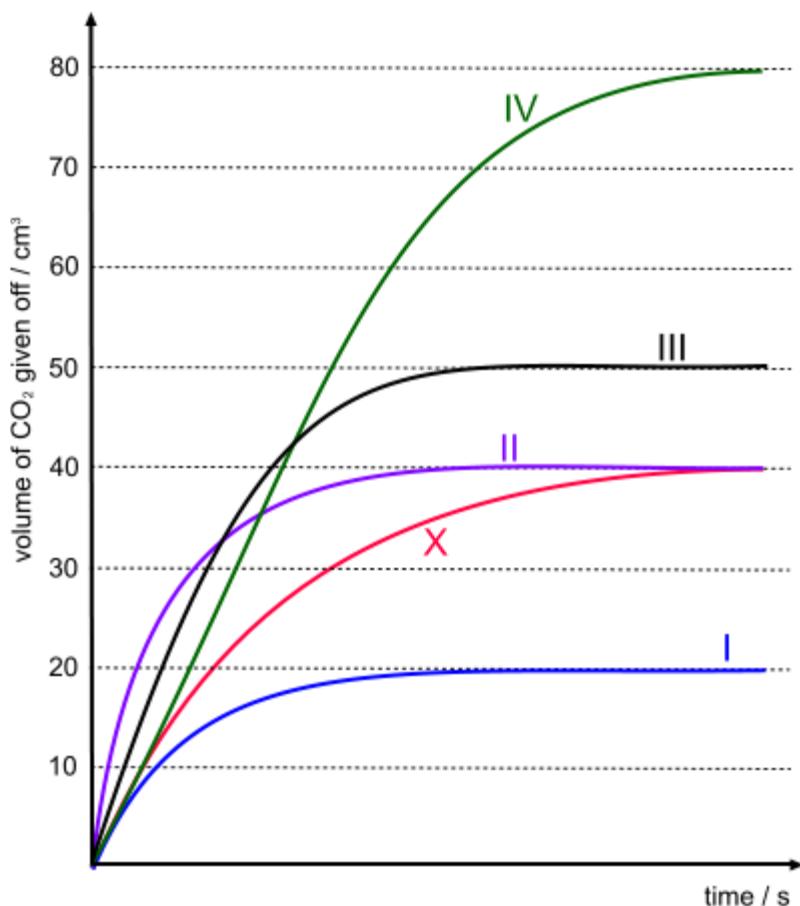


RATES GRAPHS



0.20 g of small marble chips and 20.0 cm³ of 0.20 mol/dm³ hydrochloric acid react exactly together and these were used in experiment X. Experiment X was carried out at 20°C. The experiment should have produced 48 cm³ of CO₂.

- 1 Why is less than 48 cm³ of gas collected? *Gas escaped before bung put on*

Comment on each of the following answers:

- 2 20.0 cm³ of 0.40 mol/dm³ hydrochloric acid was used in experiment IV. This was needed to produce twice as much gas.

Although there are twice as many hydrochloric acid particles, twice as much gas will not be produced as extra marble chips have not been added (the amounts given are for an exact reaction so 0.40 g of marble chips should be added). Also, the initial rate of reaction is the same as experiment X (same initial gradient), which suggests that the concentration of hydrochloric acid is probably the same (0.20 mol/dm³).

- 3 Experiment II used the same amounts as in experiment X but it must have been carried out at a higher temperature because the rate of reaction is faster but the same amount of gas was produced.

*It could have been carried out with the same amounts as experiment X as the same volume of gas is produced, however, adding more of either reactant would also not increase the amount of gas produced unless the amount of the other one is also increased, e.g. **just** adding a greater volume of hydrochloric acid would not increase the volume of CO₂ produced (the mass of marble chips would also need to be increased). It could have been carried out at a higher temperature because the rate is faster (curve initially steeper and reaction finishes earlier) but increasing the surface area of the marble chips would also have the same effect.*

RATES GRAPHS

- 4 0.20 g of medium marble chips were reacted with 20.0 cm³ of 0.20 mol/dm³ hydrochloric acid in experiment III. Although the amounts of chemicals used are the same, more gas was collected because the rate of reaction was slower and so less gas was lost at the start.

This is a possible explanation but because the maximum amount of gas that could be produced is 48 cm³ this cannot be the case here. The initial rate is faster so it looks like a higher concentration of hydrochloric acid was used and more than 0.20 g of marble chips. Using a greater mass of smaller marble chips/CaCO₃ powder (higher surface area) and a larger volume of hydrochloric of concentration 0.20 mol/dm³ would also produce this graph.

- 5 Three possibilities for experiment I (all at 20°C) are

All three sets of conditions will produce half the volume of carbon dioxide.

- 0.20 g of small marble chips and 20.0 cm³ of 0.10 mol/dm³ hydrochloric acid.
 - *The initial rate (gradient) is the same as in experiment X so the concentration of hydrochloric acid was probably still 0.20 mol/dm³*
- 0.10 g of small marble chips and 20.0 cm³ of 0.20 mol/dm³ hydrochloric acid.
 - *Half the mass of marble chips will have half the surface area so the initial rate is likely to be slower than in experiment X.*
- 0.20 g of small marble chips and 10.0 cm³ of 0.20 mol/dm³ hydrochloric acid.
 - *This has the same surface area for the marble chips and the same concentration for hydrochloric acid so this is the most likely set of conditions. This set of conditions will give the same initial rate as experiment X but half the total volume of gas.*

Decide which set of conditions probably produced the curve shown.

- 6 A set of conditions for experiment III could have been:

0.40 g of CaCO₃ powder, 20.0 cm³ of 0.25 mol/dm³ hydrochloric acid, 30 °C.

Yes, this would produce a faster rate and more gas than for experiment X

- 7 A set of conditions for experiment IV could have been:

0.40 g of small marble chips, 10.0 cm³ of 0.80 mol/dm³ hydrochloric acid, 20 °C.

This will produce twice as much gas because the mass of marble chips is twice as much as in experiment X and the total number of hydrochloric acid particles has also doubled, but the initial rate of reaction would be much faster than in experiment X (higher surface area and higher concentration of hydrochloric acid) whereas the graphs show that the initial rates are the same.