Research division, Standish Chemical Company

- Your task

To: Chemical Research Division

The crushing machinery in our quarry produces limestone chippings which are all the same size. These limestone chippings are used for a variety of purposes, one of which is to produce carbon dioxide gas by reacting the limestone chippings with dilute hydrochloric acid. This process is too slow for our needs*. As your task we should therefore be grateful if you could find out as accurately as possible how the speed of the reaction can be altered by using hydrochloric acid of different concentrations.

Please submit detailed plans for experiments to test how the concentration of the acid affects the rate of reaction. To help us estimate the time needed to complete this work, please indicate clearly how many experiments will be needed and what conditions will be used for each one.

Also indicate how any solutions you will need should be prepared. We should like to see a diagram of the apparatus for one experiment and a list of any other items you will need which are not shown on the diagram. Your report should include details of the amounts of materials to be used in each experiment and how these will be measured.

You should explain the results of your experiments as they will be used to show the relationship between the acid concentration and the rate of the chemical reaction.

* We cannot afford to install machinery to crush the chippings to smaller sizes, or the energy needed to heat the reaction vessel to a higher temperature.

Based on a suggestion by L. Ryan.

Time

70 minutes.

Group size

2–3.

Equipment & materials

Eye protection.

General
Beakers, conical flasks, conical flasks and bungs to fit them with a glass through tube, rubber tubing, gas syringes, measuring cylinders, stopclocks, cotton wool. Balances (grams) to 2 decimal places. Graph paper.

Calcium carbonate (marble chips approximately all the same size).

Dilute hydrochloric acid (4 mol dm^{-3}).

Health & Safety notes

This is an open-ended problem solving activity, so the guidance given here is necessarily incomplete. Teachers need to be particularly vigilant, and a higher degree of supervision is needed than in

activities which have more closed outcomes. Students must be encouraged to take a responsible attitude towards safety, both their own and that of others. In planning an activity students should always include safety as a factor to be considered. Plans should be checked by the teacher before implementing them.

You must always comply with your employer's procedures and in some cases may decide that a particular activity is inappropriate in your situation. Further information on Health and Safety should be obtained from reputable sources such as CLEAPSS [*http://science.cleapss.org.uk/*] in England, Wales and Northern Ireland and, in Scotland, SSERC [*https://www.sserc.org.uk/*].

Students must wear eye protection.

Hydrochloric acid, 4 mol dm^{-3} HCl (aq), is a skin/eye irritant.

(Hydrochloric acid is not corrosive until really quite a high concentration – 6.85 mol dm^{-3}! Teachers may feel more comfortable insisting on splash resistant goggles (BSEN 166 3) rather than safety specs but they are not essential for this level of hazard)

Disposal: Any remaining acid should be neutralised with weak alkali before being washed to waste.

It is the responsibility of the teacher to carry out a suitable risk assessment.

Curriculum links

Rates of reaction.

Possible approaches

It is important to tell students that the amounts of hydrochloric acid and water should be measured as carefully as possible. The easiest way to compare the results from each part of the experiment is to construct a graph. Some students may follow the course of the reaction by observing the change in mass of the reaction mixture as carbon dioxide is given off. Others may collect the CO_2 given off in a gas syringe. "This challenge would make a good 'design an experiment' assessment for GCSE". Parameters such as stirring also need to be considered.

Suggested write-up

Chemical Research Division, Standish Chemical Company

Project Planning Report

Report submitted by: …… (name)

…….... (date)

Diagram of Apparatus (label this to show the name of each item and show where chemicals are placed or products are collected).

List of other items required

Method

Extension work

Examine effect of **(i)** particle size and **(ii)** temperature on rate of CO_2 production – **NB** requires modification of student sheet.

Get students to draw a diagram of the plant, *eg* crushing machine, rollers *etc.* Is the process continuous or batch? Other questions, *eg* waste disposal, can also be considered.

Credits

Health & safety checked May 2018

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