THE EFFICIENT HOME-MADE FIRE EXTINGUISHER (II)

Introduction[1]

Many fire extinguishers, like the ones in the figure, use carbon dioxide. Although we can find fire extinguishers that work in different manners, in order that a fire extinguisher is efficient it is necessary that the carbon dioxide is released as fast as possible. CO_2 is a gas that can be obtained in the laboratory or at home as a result of a very simple chemical reaction. If we know how to obtain this gas quickly, we can make a good home-made fire extinguisher.

To address this situation we need to know the answer to next question:

Under which conditions will we obtain carbon dioxide at the fastest rate to be used as a fire extinguisher?

To answer this question you will:

- Learn or remember which variables that can modify the speed of a reaction and why.
- Design and perform experiments to modify the speed of a reaction.
- Work collaboratively to find the best answer to the problem.

PART 1 Preliminary measure: Observation of an experiment (Optional, warming up)

Introductory concepts (optional)

- Carbon dioxide can be obtained by the reaction of an acid and a metallic carbonate or bicarbonate. For example

$$CaCO_{3(s)} + 2\ HCl_{(aq)} \rightarrow CaCl_{2(aq)} + CO_{2(g)} + H_2O$$

- With this equation for the speed of CO_2 production can be written:

$$\mathbf{v} = \frac{\Delta[\mathbf{CO_2}]}{\Delta \mathbf{t}} = \frac{\Delta \mathbf{p}_{(CO_2)}}{\mathbf{R} \cdot \mathbf{T} \cdot \Delta \mathbf{t}} \quad \frac{\mathbf{mol}}{\mathbf{L} \cdot \mathbf{s}}$$

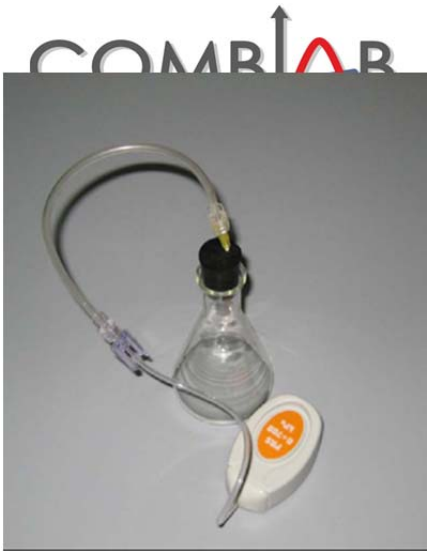
where $\Delta \mathbf{p}$ is the pressure change in the flask during the CO_2 formation.

Cite this work as:
Tortosa, Montserrat (2014). A home-made fire extinguisher (part II) pp. 1-5. Available at http://comblab.uab.cat

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein Project N. 517587-LLP-2011-ES-COMENIUS-CMP

Equivalences between pressure units

1 atm = 101.3 KPa = 1.013 Bar



- Having these premises, to obtain the speed of the reaction we will do the reaction in a closed recipient, at a constant temperature (ambient) and measuring the evolution of pressure along the time. We can use the laboratory assembly of the accompanying image

> Use security goggles
>
> They protect us from acid spills (like the HCl used in this experiment), stoppers, needles,... or anything that could be harmful for the eyes.

Part 2: Modeling the situation in the laboratory

The objective of this part is to design and to perform experiments to answer the question:

"Under which conditions will we obtain carbon dioxide at the fastest rate to be used as a fire extinguisher? "

Theoretical model: collision theory

To obtain carbon dioxide at a higher rate, the speed of the reaction has to be higher; one of the theories that explains this how does it work is the "collisions theory"

How do you think that the number of efficient collisions can be increased? That is, how do you think that the reactants or the conditions under the reaction is developed should be, so that the frequency of efficient collisions is higher?

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It is accepted that a chemical reaction happens when there are efficient collisions among the reactants' particles (atoms, molecules or ions). Due to the impacts some of the existing bonds break and new bonds are formed, this process allows the products of the reaction be

formed from the reactants. That is chemical reactions can occur only if reacting particles collide. Nevertheless not all collisions produce chemical change, some of them do not have enough energy, they are not efficient and do not yield products. Collisions with enough energy to break the existing bonds and to form new ones are called efficient collisions. Only efficient collisions produce chemical change. The number of efficient collisions determines the speed of the reaction.

Write and explain which factors or variables do you think that can increase (or diminish) the speed of the reaction between calcium carbonate and hydrochloric acid.

- ……
- ……
- ……
- ……
- ……
- ……
- ……

Now you will design an experiment (choosing the laboratory glassware and equipment that you consider) to investigate how these variables intervene in the speed of reaction. You will choose one variable, design and perform the experiment and explain your conclusions to the other groups. A common solution will be proposed.

The experiment

Choose a factor that affects the speed of the reaction	
Experiments you will perform (draw and write a short description of them)	
What experimental data do you need. Which	

evidences will you use?	
What will you do so the other variables considered before don't affect your experiment?	
Prediction of the results	
Prepare a table (or the axes for the graph) to write the results obtained.	

Evaluating results

a) Evaluate the data that you have obtained and compare them with your predictions:
In what are they similar?

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How do you explain these similarities?

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How do they differ? Why?

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b) Conclusions of your experiment: ……

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Share your results with the other groups, discuss in a plenary session to agree on a suitable answer to the main question, write it:

Under which conditions will we obtain carbon dioxide at the fastest rate to be used as a fire extinguisher?

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Questions

a) How does the speed of the reaction between hydrochloric acid and calcium carbonate evolve along the time? ……
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……

b) It was easy for our group to design our own experiment.
1 , 2, 3, 4, 5 (1: strongly agree 5: strongly disagree)
Please explain your answer……
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……
……

In-depth activities

a) Do you think that the studied chemical reaction can be done at home with everyday materials? ……
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b) Write at least one other reaction in which you can obtain carbon dioxide using household ingredient ……
……
……

c) Design a household fire extinguisher taking into account what you have learned
d) Test your fire extinguisher, how does it work? Attach a picture or a video document of it

References

Tortosa M. (2006). Ràpid, hem d'apagar foc. Labsheet used at Revir workshops (2006-2009) http://crecim.uab.cat/revir/ . In Catalan. Unpublished.