Scan the QR-CODE to see the **video**

## Air Activates Heat-Packs
A different kind of corrosion

## Heatermeals – Hot Food Anytime & Anywhere
Corrosion, local cell, passivation and sacrificial anode all in one

## ChemZ – Experimental Kits with Plastic Syringes and more
An equipment overview

## ChemZ – Further Ideas
$O_2$, $CO_2$, or $H_2$

## Qualitative Analysis
What kind of gas comes out of a fizzy tablet?

## Quantitative Analysis
How much gas comes out of a fizzy tablet?

## Solution of $CO_2$ and the Le Châtelier's Principle
Influence of temperature

## Solution of $CO_2$ and the Le Châtelier's Principle
Influence of pressure

## Le Châtelier's principle and the Formation of a Dripstone Cave
Calcium carbonate ($CaCO_3$) … circulation … ($CO_2$, $HCO_3^-$ an $CO_3^{2-}$)

## Solution of $CO_2$ and the Le Châtelier's Principle
Marine carbon chemistry, ocean acidification

## Working with acids, kinetik, easy titration and more
Never search a fitting part for your burette again

# AIR ACTIVATED HEAT-PACKS
A different kind of corrosion

**M| 1 Request**

*M|1 Letter to the editor:*

Due to my occupation, I often deal with painful hardening in the neck area. Because of their pain-relieving effect, I'm interested in self-heating patches like "BodyWarmer". I would like to find out how they work exactly. Also, I would like to know if I can only use them once or several times.

In the advertisements they are said to be activated by air. Is this true? Are they harmless or may they cause any problems?

Would you be so kind and help me? Thank you in advance for your help.

Susanne Musterfrau, Cologne




**M|2 Task**

*M|2 Task:*

Your task is to examine the functionality of the self-heating patches with the help of the experiment kit and the enclosed learning materials in order to provide an answer to the reader's question.

You should follow these steps:

1. Write down questions that you need to answer in order to explain the functionality of the self-heating products.
2. Use the materials and experiments to find answers to your questions and document your process. If you need help or want to go on, you find some hints in M|5 to M|7.
3. Write a short but meaningful letter of reply, in which you explain the functionality of the self-heating patches in a way that readers with know-how in chemistry are informed adequately.
4. When you've finished steps 1. – 3., there is the option of discussing other aspects concerning the self-heating patches (e.g. see letter to the editor). Take notes on the questions and discussed answers.

**M|3 and M|4 further information**

*M|3 Excerpt of the package leaflet: How do self-heating warmers work?*

*[…] Bodywarmer contain ingredients like iron, activated carbon, salt and water. Once these ingredients come into contact with air, the ingredients react and produce heat. The combination of ingredients was specially formulated to ensure a constant and comforting heat for a wide variety of uses. The saltwater and the activated carbon only accelerate the reaction.*

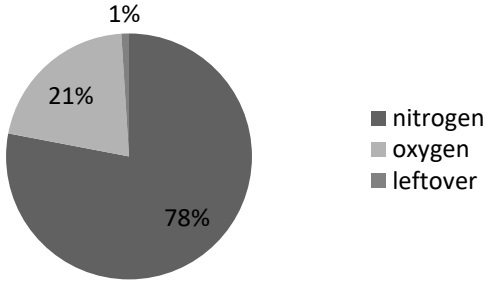
*M|4 Information about rust*

The reaction of iron, water and oxygen produces rust, which h all of you know

Normally we try to stop this process because rust leads to destruction and cannot be undone easily.

**M|5 Air composition**

*M|5 Figure for air composition*



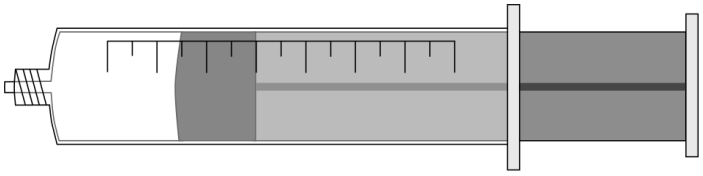

*Think further: For further thought:*

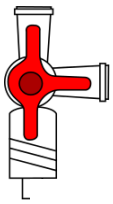
- "air-activated" – Can one of the main components of air alone activate the body heater?
- Can you investigate experimentally how much oxygen is in the air by using a bodywarmer?

**M|6 Hints for using the syringes**

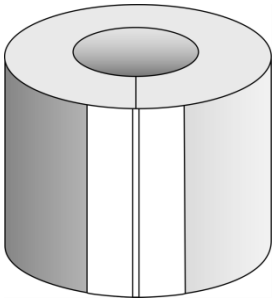
*M|6 Hints for using the experimental kits with plastic syringes*

Syringes can be used to test the substances of the body heater in a limited aerial volume.

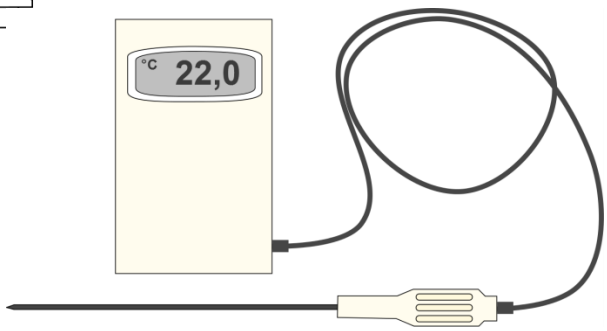




By means of a three-way valve, you can close the syringe or add gas from a second syringe.



You can attach a temperature sensor to the syringe by means of a PE pipe isolation.

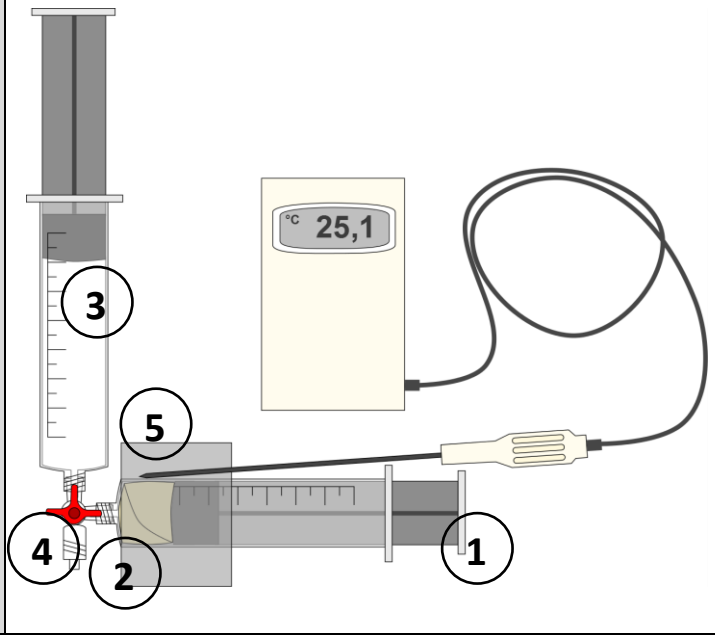



The substances of the body heater would soil the syringe. 2 spoon spatulas of it can be wrapped in a paper towel or tea bag before they are inserted into a syringe without a plunger.

**M|7 Possible setup**

*M|7 Possible experiment setup*

You can examine the change in temperature and in volume when using air, pure oxygen, or pure nitrogen. In order to test it, take a plunger (1) out of the syringe.




Approx. 2 spoon spatulas of the body heater substance are wrapped in a tea bag (2) and then inserted into a syringe without the plunger.

Insert the plunger again and push all air out of the syringe.

After that, gas is pulled into the other syringe (3). Connect both syringes by the three-way valve (4), and add the gas to the body heater substance. You can attach a temperature sensor to the syringe by means of a PE isolation.

## M|1 Background

*M|1 Background*




You are a researcher for a scientific television programme. The producers of the show often receive questions from viewers; questions that are answered experimentally during the programme.

One of the questions sent in is the following:

"While browsing the Internet, I came across a product that caught my attention – self-heating meals. I read that individual meals are wrapped in a bag containing magnesium, and that if you pour salt water into this bag, the bag begins to inflate, steam is produced and the food heats up.

"Allegedly, a dangerous gas and a 'lye' are formed during the reaction. Can you tell me if this is true?

"Also, I have tried making such a bag myself, by pouring salt water onto magnesium, but it didn't really work. Where did I go wrong?"

## M|2 Task

*M|2 Task:*

Your task is to develop a script for the programme dealing with the viewers' questions and presumptions.

Design experiments to identify the products that are formed during the reaction and draw a short cartoon sequence explaining the reactions in the local cell at the molecular level

Be prepared to carry out your concept in a simulated editorial meeting. In doing so you will learn subject content and terms concerning the topics of corrosion and corrosion protection, which you need for your response.

## M|3 product description

*M| 3 Product description Translated from the supplier's website (www.dauerbrot.de).*




Open the packaging and remove the contents, then place the unopened aluminium bag containing the meal into the 'heating bag', which contains a magnesium compound. Pour the content of the small bag containing liquid into the heating bag, crease the 'heating bag' as far as possible/fold the top of the bag over and close it with the provided tape strip. The bag will start to heat up. Wait 10-12 minutes and the meal will be hot and ready to eat.

Safety note: remove the meal carefully as the heater bag, salt water and meal will be hot (100°C). Taking care not to burn yourself, pour away the liquid; after cooling down, the heater bag can be safely disposed of in household waste and the rest of the packaging can be recycled.

## M|4 Hints

Experiments can give an answer to the viewers' presumptions (gas? lye?)

Try to make a heater on yourself, using only magnesium. For that you can put magnesium powder in salt solution with phenolphethalein.

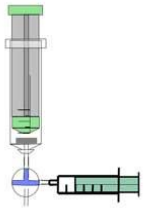
Does it work? Explain why (not).

What is the difference between you self made heater and the one, you can buy?

**M|5 Experiments**

*M|5 Experimental hints*

Wear safety goggles! For safety reasons (risk of evolving hazardous substances, releasing energy, possible 'run-away' reactions) use the following instructons:







**Important Information**

- Children should use only with adult supervision.
- Heater Meals do not produce Carbon Monoxide (CO), but may activate CO detectors.
- Do not consume non-toxic Food Heater.
- Enclosed water is not for drinking.
- This product only reacts with salt water sachet - not standard tap water.
- Always use in a well ventilated area, away from fire or flame.
- Activated Food Heater produces heat and steam.
- Do not microwave.

1. Put the metal powder mixture into an empty tea bag and stuff this into a 50 ml syringe (without the tea bag, the powder could block the syringe). Press out the air.
2. Fill the 20 ml syringe with salt water, add one droplet of phenolphthalein solution and connect it to the large syringe using a three-way valve.
3. Turn the valve to let the two materials flow together in the closed system.
   As the reaction proceeds, gas will accumulate in one of the syringes. As soon as more than 25 ml of gas has accumulated, open the valve and let the gas out by using a tube and a bowl of water to collect it in a test tube (as shown in the diagram).
4. Perform the test for hydrogen far away from the syringe by holding the mouth of the test tube in a flame (see diagram), making sure you hold the top of the tube close enough to the flame.

Health and safety note: the remaining liquids can be disposed of in the sink. Clean the plastic materials with water and leave to dry. Hint: the salt in the salt water is not important for the reaction equation.

**M|6 – M|8 Further explanations**

***M|6 Explanation of passivation***

Passivation denotes the formation of inert surfaces on normally very reactive metals, which prevents the underlying metal from corroding. Passivation occurs with many reactive metals, such as magnesium or aluminum, because the metals react to form an impermeable and strongly adhering surface layer of oxides or hydroxides. As a result, the metals are unaffected by chemicals with which they would otherwise react strongly - their behaviour is similar to that of noble metals such as gold.

***M|7 Additional information***

For detailed information on content, see the United States patent 5,611,329 (with commas between the numbers), or B1019094.0 which can be consulted online.

***M|8 Note on local cells***

If metals with a different nobility contact each other in a conductive medium (water or acid), the less noble metal will corrode much faster than usually. This is because in such 'local cells', oxidation and reduction reactions occur in separate places.

For example, when in contact with a less reactive metal in water, magnesium forms magnesium cations ($Mg^{2+}$). The electrons released by the magnesium flow through the less reactive metal and into the water, leading to the formation of hydrogen ($H_2$) and hydroxide ions ($OH^-$) at the surface of the less reactive metal, rather than on the magnesium surface. Therefore, a 'protective layer' of magnesium hydroxide cannot form on the magnesium, and there is no passivation.

This principle is used in self-heating meals: using a magnet, you can demonstrate that the 'heater bag' not only contains magnesium, but also iron.

For explanation of the functionality of the local cell with the US patent, see http://www.on-line-foods.com/tech_paper/AKShah.pdf (access on 30.03.2014)

# “CHEMZ“ – EXPERIMENTAL KITS WITH PLASTIC SYRINGES UND MUCH MORE
equipment overview



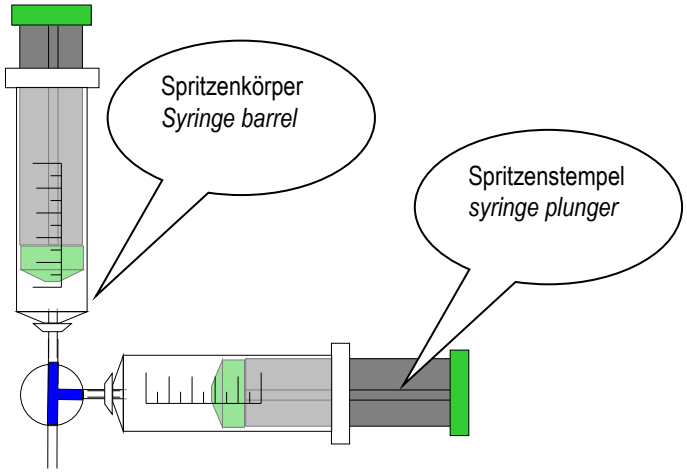
Luer (-Lock) Spritzen in verschiedenen Größen: Reaktionsräume, Gasentwickler, Messinstrumente oder Büretten u. v. m
*several syringes with luer or luer-lock fitting: space for reactions, generating gases or measuring tools e. g. for titration*



Dreiwegehahn –Absperrhahn
*3-way-stopcock(valve) - to close or connect syringes*



Kombistopfen als gasdichte Verschlussstopfen
*syringe cap*






Verbindungsstück zwischen zwei Spritzen („weiblich-weiblich“), starr oder auch flexibler mit Schlauch.
*connector female/female (fix or flexibel)*



Universalschlauch – verbindet alles. Pneumatisches Umfüllen von Gasen
*Universal tube – fits on any syringe or cock – pneumatic transfer gas to test tube*



Hahnenbänke für viele Spritzen
*Several-3-way-stopcock in a row -to connect a lot of syringes*



Kleiner $CO_2$-Spender
*$CO_2$ Donator - fits to syringe*



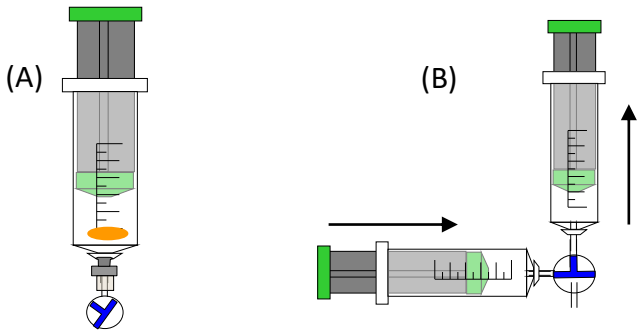


Verbinder: Gasflasche – Schlauch – Spritze
*connector/adapter: pressurised gas cylinder – tube - syringe*

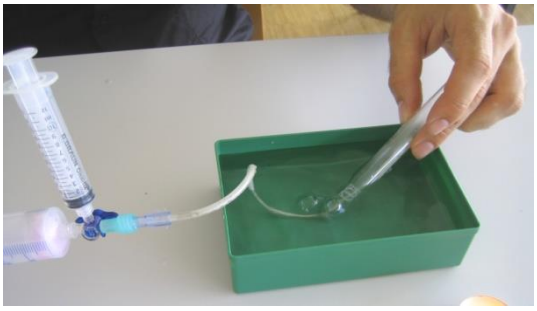
# "CHEMZ" – FURTHER IDEAS

$O_2$, $CO_2$ or $H_2$

**You can use syringes to produce gases in a small amount and very simple way (A) or (B):**




(C)



Put the solid reagent in a syringe (e. g. a fizzy tablet or $CaCO_3$ to produce $CO_2$ or a short peace of magnesium ribbon to produce $H_2$).

Press all air out and close the syringe by a valve.

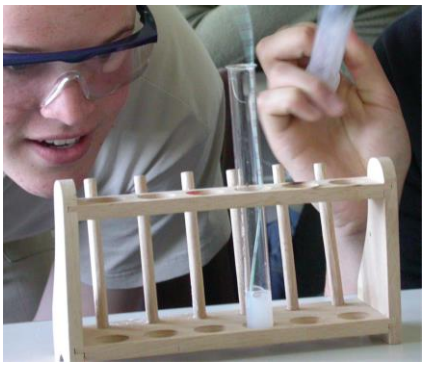
Pull the liquid reagent (water, HCl etc. …) into the syringe. You can use a second syringe for doing that.

Close the valve and wait until you have collected enough gas. Open the valve an let all liquid out to stop the reaction!

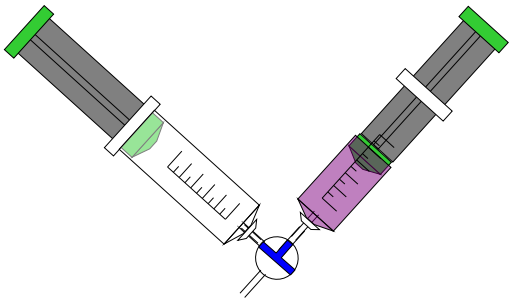
You can also directly collect the gas in a test tube (C)

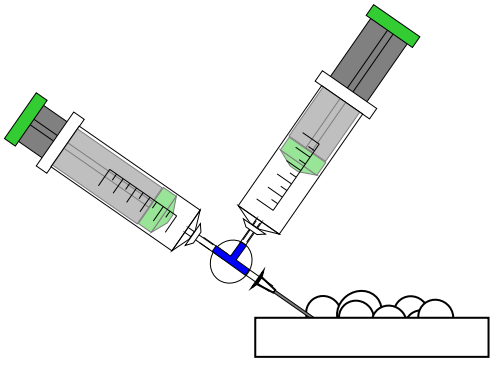
**Some simple experiments with the gases:**

- traditional limewater test for carbon dioxide or the tests in a test tube for oxygen or hydrogen
- acidity of carbon dioxide by using an indicator
- built a fire extinguisher
- or show that Hydrogen bubbles are flammable and a mixture with oxygen is explosive









## QUALITATIVE ANALYSIS

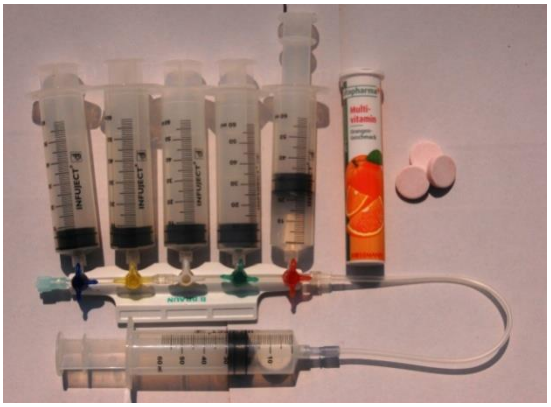
What kind of gas comes out of a fizzy tablet?

- Possible setup: Remove the plumber of a 50mL syringe and put a **part** of a fizzy tablet in the tube. After putting back the plumber to the tube the room for the reaction is ready.
- One more syringe has to be filled with water and get connected to the other one by a 3way stopcock. Fill the water to the part of the tablet and observe the beginning reaction. The liberated gas can be contained in the second syringe.
- At the end the lime water test proofs that it is $CO_2$.



## QUANTITATIVE ANALYSIS

How much gas is in a fizzy tablet?



- Possible setup: Take the manifold and some 50/60 mL syringes. Remove the plumber of one syringe and put a fizzy tablet in the tube. After putting back the plumber to the tube the room for the reaction is ready.
- One more syringe has to be filled with water. We need about 30 mL water. Connect all syringes to the manifold. Put the water to the syringe with the tablet. Perhaps you need some helping hands for the coming reaction.
- Fill the gas syringe by syringe and notice the complete volume.
- Depending on brand and issue you will get up to 400 mL of $CO_2$.

And for **experts** it´s interesting to do the experiment like this:

- Take the same setup but more than 30 mL of water and break the tablet in two equal parts. And now solve one half after the other in the SAME water. What do you expect: **How much gas will come out of the part half of the fizzy tablet?**

## SOLUTION OF $CO_2$ AND LE CHÂTELIER'S PRINCIPLE

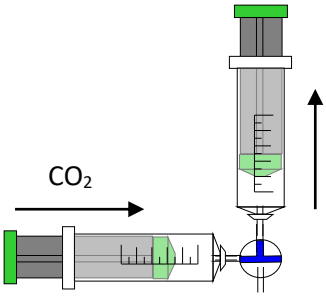
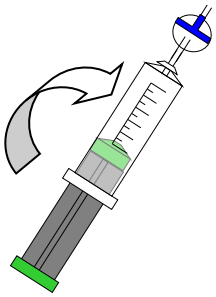
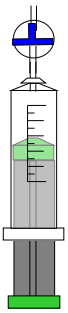
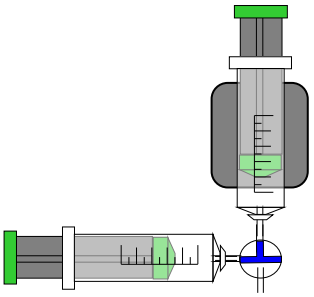
Influence of temperature

$CO_2\,(g) \xrightleftharpoons{H_2O} CO_2\,(aq) \quad |\ \Delta H<0$

$CO_2\,(aq) + H_2O \rightleftharpoons H_2CO_3$

$H_2CO_3 + H_2O \rightleftharpoons H_3O^+\,(aq) + HCO_3^-\,(aq)$




| | | | |
|---|---|---|---|
|   |  |  |  |
| 30mL $CO_2$ are given in another syringe to 25mL water (≈23°C) … | … shake it … | … till no further gas is soluted … note and try it again …. | … twice by using warmer or colder water (≈ 0°C/≈ 50°C) and use an isolation. |

## SOLUTION OF $CO_2$ AND LE CHÂTELIER'S PRINCIPLE

Influence of pressure

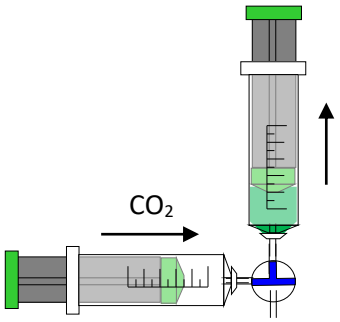
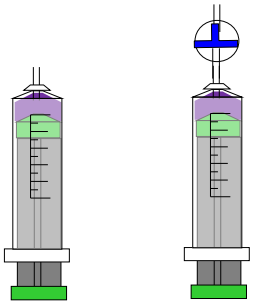
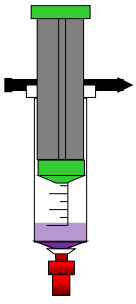


$CO_2\,(g) \xrightleftharpoons{H_2O} CO_2\,(aq) \quad |\ \Delta H<0$

$CO_2\,(aq) + H_2O \rightleftharpoons H_2CO_3$

$H_2CO_3 + H_2O \rightleftharpoons H_3O^+\,(aq) + HCO_3^-\,(aq)$



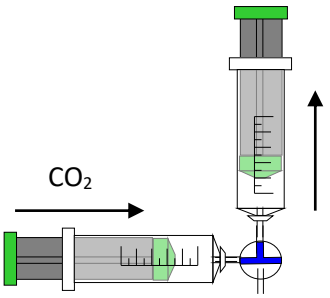
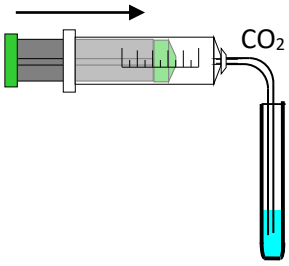
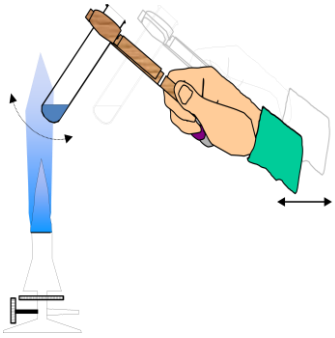
| | | |
|---|---|---|
|   |  |  |
| Put a few droplets of tashiro-indikator to water, fill 10mL of the solution in a syringe and add $CO_2$ till its satured. | Divide the solution to both syringes (5mL/5mL) … close one syringe by the valve … | … pull the plunger to reduce the pressure. You can fix it by a nail! Shake it …compare the colours! |

# LE CHÂTELIER'S PRINCIPLE AND THE FORMATION OF A DRIPSTONE CAVE

Calcium carbonate ($CaCO_3$) … circulation … ($CO_2$, $HCO_3^-$ an $CO_3^{2-}$)



$CO_2(aq) + H_2O + CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + 2\ HCO_3^-(aq)$

| | | |
|---|---|---|
|   |   |  |
| Produce "fresh" limestone by adding a lot of $CO_2$ to $Ca(OH)_2(aq)$ … and shake it for 30s. | … you can also do it like this. Fill the tube nearly by soda (mineral water) and shake it | … you get a clear solution, which you can boil to produce limestone again, cause $CO_2$ will disappear. |

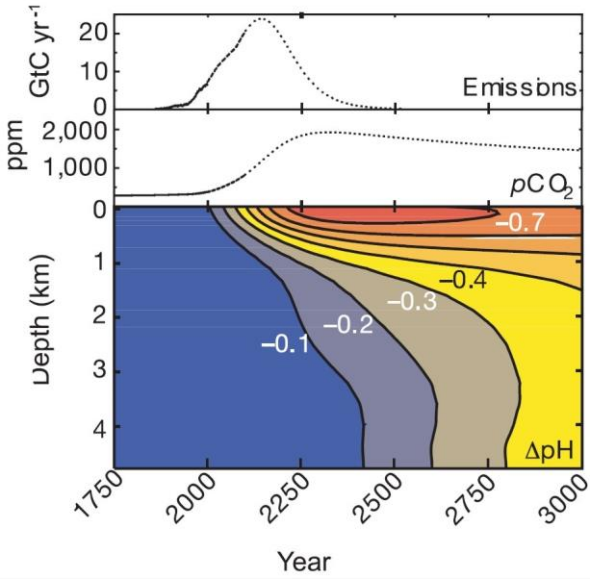
# SOLUTION OF $CO_2$ AND LE CHÂTELIER'S PRINCIPLE

Marine Carbon Chemistry, Ocean Acidification

$CO_2(aq) + H_2O + CaCO_3(s) \rightleftharpoons Ca^{2+}(aq) + 2\ HCO_3^-(aq)$; the same Experiment in another context!

Fig. A taken from "Climate Change 2007", the Fourth IPCC Assessment Report, S. 529 and Fig. B "the number and location of calcium-carbonate shelled plankton species have changed since 1960" taken from http://ocean.si.edu/ocean-news/searching-ocean-acidification-signal (12.06.2015).

(A)



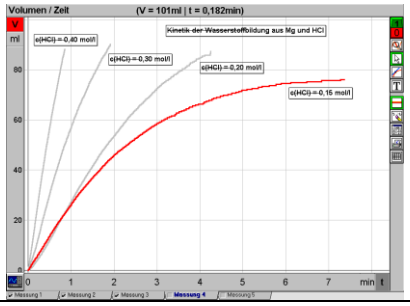

(B)



# WORKING WITH ACIDS, KINETIK, EASY TITRATION AND MORE

Never search a fitting part for your burette again

Cause the syringes can be filled with HCl (1mol/L) you can determinate the reaction speed, examine how much $CaCO_3$ is in antacida (stomachic) or how lime dissolver work:

| | |
|---|---|
|  | Volume versus time: How much hydrogen is produced?<br>Use magnesium ribbon and HCl (c=diverse)<br>$Mg(s) + 2H^+ + 2Cl^- \rightleftharpoons Mg^{2+}(aq) + H_2(g) + 2Cl^-(aq)$<br> |
|  | $CaCO_3(s) + 2H^+ + 2Cl^- \rightleftharpoons Ca^{2+}(aq) + H_2O + CO_2(g)$<br>Collect all gas (pV=nRT) or solve a tablet in 20mL HCl (1mol/L) an titrate with NaOH (1mol/L) |
|  | Which gas is produced?<br>$CaCO_3(s) + 2H^+ + 2Cl^- \rightleftharpoons Ca^{2+}(aq) + H_2O + CO_2(g) + 2Cl^-(aq)$<br>$Mg(s) + 2H^+ + 2Cl^- \rightleftharpoons Mg^{2+}(aq) + H_2(g) + 2Cl^-(aq)$ |

And you can use syringes in different ways for titrations, all of them work as well:

