ACID-BASE REACTION SCIENCE EXPERIMENT

Ages 11-14 (Level 3)

Description:	Teach your child how to conduct and report on scientific experiments with this simple acid-base reaction experiment
Leading question:	How would a scientist conduct and report on an experiment?
Age group:	11-13 year old
Subjects:	Science – chemistry
Total time required:	20-40 mins a day for 10 days (total of ~5 hours)
Self-guided / Supervised activity:	Low supervision by parents or guardians/mostly self-guided
Resources required:	• Notebook, pen/pencil, glass jar, vinegar, egg, spoon, measuring tape or string, rubber band, or thread, Purple cabbage, knife or blender or hot water, bowl or container, 5 or more clear plastic glasses or cups, sheets of plain white paper, marker, large teaspoon

Learning outcomes	• Understanding acid-base indicators • Understanding acid-base reactions • Able to work scientifically • Able to setup and do scientific experiment • Able to present scientific findings • Presentation and communication skills
Required previous learning	None
Inspiration	Naked Eggs: Acid-Base Reaction

Topics/concepts covered and skills developed
• Acids and bases • Acid-base indicators • Acid-base reactions • Household acids and bases • Vocabulary – hypothesis, neutralization • Working scientifically • Setting up and doing a scientific experiment • Writing a scientific experiment report • Presenting research findings

EAA welcomes feedback on its projects in order to improve, please use this link: https://forms.gle/LGAP9k17fMyJrKJN7

Day	Time	Activity and Description
1	5 minutes	The learner will be conducting an experiment with the objective of learning about the scientific method and how scientists work. They will accomplish this through an activity where they will observe an acid-base reaction in real life by exploring what happens to eggs that are placed in vinegar, and present their findings
	15 minutes	Ask the learner what she or he thinks will happen when eggs are submerged in vinegar? What happens when an acid and base mix? The learner will review appendix 1 to learn about acids and bases. Main takeaways: ● The difference in properties between acids and bases- ex: acids turn blue litmus paper red while bases do not change the color of blue litmus paper; acids do not change the color of red litmus paper while bases turn it blue; acids are sour while bases are bitter and soapy ● Examples of each: acids - citrus fruits, vinegar; bases - soap, baking soda etc. ● Neutral substances have a pH of 7 while acids have a pH below 7 and bases above 7. Lower numbers on the pH scale indicate stronger acids while higher numbers indicate stronger bases. ● ***Neutralization***: when acids and bases react, they cancel each other's effect and the result is salt, water and energy in the form of heat ● Illustrate neutralization as: acids + bases ⟶ salt + water. e.g. NaOH + HCl ⟶ NaCl + H_2O. P.S.: you can ask the learner true or false questions to check for their understanding after you review the unit. Examples: vinegar is an example of a base (false); acids and bases do not react (false); bases have a pH of 7 and above (true) **You can refer to appendix 1 for an overview of acids and bases.**
	5 minutes	The learner will write down what they think will happen as a result of conducting this experiment. Explain that this educated guess is called a ***hypothesis*** and that scientists and researchers conduct experiments to test hypotheses, just like she or he will be doing!
	10 minutes	The learner will elaborate on their hypothesis using scientific concepts – what happens when a base and acid react? Once the learner has a good grasp of the concepts, ask them whether they think neutralization is real and if it can be observed in real life. Get them excited about the experiment by saying this will be their chance to test this phenomenon in real life!
	20-30 minutes	The learner will have all required materials ready and start the report by entering and filling out the following sections: ● Objective of experiment ● Equipment used

		• Hypothesis
2	10-20 minutes	The learner will prepare the materials needed (namely, egg, jar and vinegar) and measure the egg's circumference and set up with minimal supervision if possible: • Measure and record the circumference of the middle portion of the egg in cm • Place the egg in a jar, cover it with vinegar and store in a safe place. You should see bubbles forming at the surface of the shell Note: if you do not have measuring tape, use a piece of string or thread, or a broken rubber band to measure the circumference: • Wrap the thread or string tightly around the egg, but make sure you are gentle enough so as not to break it • Make sure your finger is placed at the point where the end of the string and the rest of it meet as shown below.  Source: https://www.gettyimages.ae/photos/turkey-egg?mediatype=photography&phrase=turkey%20egg&sort=mostpopular • Mark the point where the string/thread/rubber band meet with a pen • Use a ruler to measure the length of the string or thread from the end to the point that is marked • Record the circumference
	5-10 minutes	The learner will enter and complete the setup/apparatus section of her/his report in the notebook with details of measurement and timing of submersion. Learners can also take a picture to document the setup of the experiment, if a camera or phone camera are available.
	5-10 minutes	The learner will document what he or she saw when the egg was first submerged (bubbles forming) and what he or she expects to see tomorrow
	5 minutes	Numeracy activity: Calculate the circumference of a circle with a radius of 4cm. (hint: circumference of a circle = πd)

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<td>3</td>
<td>5 minutes

10 minutes

30 minutes</td>
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The learner will replace the vinegar in the jar after 24 hours have passed and re-submerge the egg in fresh vinegar. Leave it undisturbed in the jar for a week

The learner will record what is happening, the changes being observed and what he or she expects to happen at the end of the experiment in the table below

<table>
<tr><th>Day</th><th>Description of eggs</th></tr>
<tr><td>1</td><td></td></tr>
<tr><td>2</td><td></td></tr>
<tr><td>3</td><td></td></tr>
<tr><td>4</td><td></td></tr>
<tr><td>5</td><td></td></tr>
<tr><td>6</td><td></td></tr>
<tr><td>7</td><td></td></tr>
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The learner will make his/her own acid-base indicator from purple (sometimes called red) cabbage and use the cabbage solution indicator test which household chemicals/solutions are acids and which ones are bases. Purple (red) cabbage is a great pH indicator.

Fig. 1: Purple (or red) cabbage

Purple (red) cabbage juice contains a pigment called anthocyanin or Flavin, which is a natural pH indicator that changes color when it is mixed with an acid or a base. Cornflowers and grapes have this pigment as well. When it comes in contact with an acid, this juice turns into a pink color (weak acids) or red color (strong acids). When it comes into contact with a base, it will turn into a blue, green or yellow color (weak bases).
Materials needed:
● Purple cabbage, knife or blender, bowl or container, hot water, 5 or more clear plastic glasses or cups, sheets of plain white paper, marker, large teaspoon
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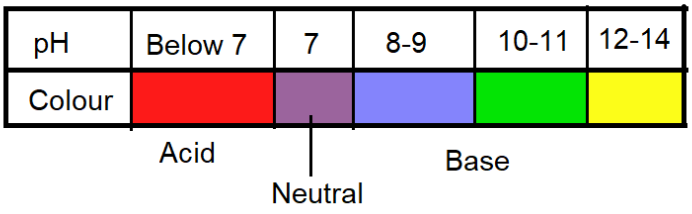
Known acid and base like: vinegar (acetic acid), water (neutral), bleach or liquid soap (base)

Procedure:
The learner will follow the following steps:
(i) Cut the purple cabbage into pieces and add them with some water to a blender and blend for a couple of minutes. If you do not have a blender, put the pieces in hot water in a bowl/container and stir and crush the leaves with a large spoon to make purple cabbage juice. Leave the juice to cool.
(ii) Strain the colored cabbage extract into a clear bottle or container. Use a sieve to get rid of all the little pieces of cabbage. This purple colored solution is the cabbage solution acid-base indicator.
(iii) Pour some vinegar (acid), water (neutral) and bleach/soap (base) into separate labelled clear plastic glasses or cups. Using an eye dropper, add a few drops of the cabbage solution indicator to each glass or cup
(iv) Record your observations in the table below

<table>
<tr><th>Chemical/solution</th><th>Acid or base or neutral</th><th>Colour of indicator</th></tr>
<tr><td>Vinegar</td><td>Acid</td><td></td></tr>
<tr><td>Water</td><td>Neutral</td><td></td></tr>
<tr><td>Bleach</td><td>Base</td><td></td></tr>
</table>

(v) Write down your conclusion from the experiment

Hint: Depending on whether the chemical is a weak or strong acid the cabbage solution will turn to pink/red color. Pending on whether the chemical/solution is a weak or strong base, the cabbage solution will turn to blue/green/yellow color.

Purple cabbage pH indicator


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<td>4</td>
<td>5 mins</td>
<td>Every morning, check on the state of the egg without taking it out of the jar. You only need to replace the vinegar after the first day. Record your observation of the changes to the egg in the table you made yesterday.</td>
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30 mins

Today, learners will conduct an experiment using their pH indicator. In this experiment, learners will use their purple cabbage pH indicator to find which of the foods and household chemicals are acids and which are bases.

Materials needed:

- Purple cabbage solution acid-base indicator, eye dropper, 10 or more clear plastic glasses or cups, marker, sheets of plane white paper.
- Household chemicals/solutions. Examples: Lemon juice, laundry power, orange juice, soda water, egg whites, Dettol, washing detergent, baking soda (bicarbonate of soda) solution, milk, liquid soap, ammonia, toothpaste solution, bleach, vinegar, soapy water, milk of magnesia etc.

Procedure

The learner will follow the following steps:

(i) Pour some household chemicals/solutions you want to test into separate labelled clear plastic glasses or cups.

(ii) Predict whether the household chemicals are acidic, basic or neutral

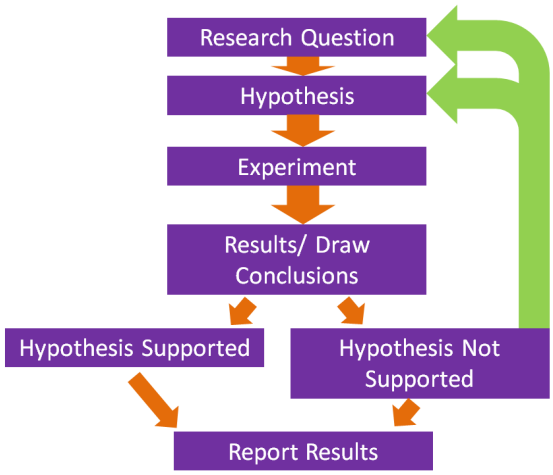
(iii) Using an eye dropper, add a few drops of the cabbage solution indicator to each glass or cup to test your prediction.

(iv) Record your prediction, observation and finding in the table below

Test household chemical/ solution	**Prediction (Acid or base?)**	**Indicator Colour**	**Result**
Vinegar	Acid	Red	Acid
Lemon juice			
Baking soda			
Orange juice			
Soda			
Water			
Ammonia cleaner			
Milk			
Lemon juice			
Tonic water			
Egg whites			
Milk of magnesia			

Literacy Extension

	20 mins	The learner will write an article on “the uses of acids and bases in our homes” for a school magazine or for a local newspaper. The article should include: ● The names of the acids and the bases and the household products in which they are found ● How can one identify whether a household is acidic, basic or neutral? ● What each of the base or acid is used for? Learners will share this article with family members or their classroom
5-9	10 minutes 30-60 minutes	Check on the state of the egg in the jar without taking it out of the jar. Ask the learner about what he/she observes. Have a conversation about the changes he/she is seeing. The learner should update their report in their notebook with all relevant observations The learner will spend 10 minutes daily working on their final presentation on a big chart paper. The presentation should include the following sections: ● Driving question of project as header ● What is the objective of your experiment? (Write 1 paragraph introducing it) ● What did the set up consist of? What materials did you use? ● Can you illustrate the set up? (Draw an illustration of the set up with all the tools used – container, vinegar, egg, spoon, measuring tape etc.) ● What is your hypothesis? (Write down the hypothesis from day 1 and do some research to find out and write Down the formula for this chemical reaction. The learner can also refer to their textbook for this or other examples of acid-base reactions.) ● What did you observe each day? ● What were the results at the end of the experiment? What daily changes were observed? Was our hypothesis supported? ● What is your conclusion/main takeaway from the experiment? (Write a paragraph on this covering the following:) o What makes up the main component of the eggshell? Is it an acid or a base? o What makes up vinegar? Is vinegar an acid or a base? o When you first cover the egg with vinegar, why do bubbles form on the eggshell surface? o What evidence is there of a chemical change? o What chemical reaction is involved to make the eggshell dissolve? o What occurs between the eggshell and vinegar? What is the result? o What is the chemical formula for the reaction between vinegar and the eggshell? o What is keeping the egg contents from spilling out?

	(10 minutes)	o Is there a difference between the size of the egg at the beginning and at the end of the experiment? What changed? What has caused this change? Refer to appendix 4 for details of the results of this experiment • What are some real life applications and uses of neutralization (in day to day life, industry etc.)? (The learner can refer to their textbook, find online resources, or ask an adult!) • What did you learn about being a scientist? • Can you explain the scientific method through either a paragraph about how you used it, or an illustration such as the one in the following diagram? Refer to appendix 4 for a detailed explanation  Source: https://courses.lumenlearning.com/suny-nutrition/chapter/1-13-the-scientific-method/ Ensure that learners include all or most of the points above in their final presentation Optional and internet access dependent tip: To make these quieter days of the project more exciting, the learner can post photo/video/"boomerang" updates of the egg (without taking it out of the jar) starting from day 1 of the experiment. Let her or him have some fun with it by posting it on stories, asking story questions and/or making polls on their social media account. The learner can also create a separate Instagram account for the egg or their projects in general. They can add their friends and post project updates of individual or group projects conducted remotely!
10	5-10 minutes	A week later, the learner will take out the egg from the jar, discard the vinegar, clean the jar and store it away

	2 minutes	The learner will measure the circumference of the egg again and record it in the notebook
	15-20 minutes	The learner will reflect on, discuss the changes he or she observes, and record them in the results and conclusion sections: ● Why has the acid (vinegar) reacted in this manner with the base (eggshell)? ● How do the results compare to the hypothesis from day 1 of the experiment? ● Do all acids and bases have the same reaction? ● What is another experiment we can try to test this?
	20-30 minutes	The learner will make final modifications to their chart and present their findings to the family! Note: you can also shorten the activity by taking out the egg 4-5 days after the initial vinegar replacement on day 3. Optional: the learner can write a scientific report on their experiment using the format provided in appendix 2 and present it to their family or classroom instead of the presentation.
Assessment Criteria:		- Successful production of cabbage solution acid-base indicator - Successful identification of acids and bases among household products - Successful completion of experiment and achievement of dissolved outer shell and translucent egg with inner membrane intact - Complete report with the following sections: objective, hypothesis, observations (day 1-7), results and conclusion - Presentation of findings and experience as a scientist

Additional enrichment activities:	- You can help the learner explore the concept of adding variables to a scientific study by comparing results across different types of eggs (free range vs commercial, quail vs hens, fresh vs old etc.) or type of liquid by testing the reaction of eggshells to water, soda etc.) - Learners can write a scientific report using appendix 2 instead of a presentation
Modifications for simplification	Learners can shorten the project by keeping the egg in the jar for 4-5 days instead of 7. They can also limit the number of activities and experiments conducted to the main one.

Appendix 1: OVERVIEW OF ACIDS AND BASES

ACIDS

When most hear the word “acid”, they think of something very dangerous that can dissolve metals and burn skin. In fact, many acids are not dangerous at all. Some are even found in the food we eat. Any food that tastes sour is acidic.

Food	Acid it contains
Vinegar	Acetic acid
Oranges and lemons	Citric acid
Apples	Malic acid
Vitamin C	Ascorbic acid
Wine	Tartaric acid

Properties of acids

Characteristics of acids
A sour taste. Try drinking lemon juice
Turns blue litmus paper red
Conducts electricity when dissolved in water
Corrosive to metals
Releases hydrogen ions (H^+) in solutions
Reacts with bases in neutralization reactions
Have a pH < 7

BASES

Bases are also found in common household products. Strong bases are dangerous but weak bases are safe to use. Bases have a bitter taste and have opaque colouring. Bases are not used in our foods. Weak bases are often used as cleaning products e.g. household ammonia is used to clean windows.

Properties of bases

Characteristics of bases
A bitter taste. Try testing milk of magnesia

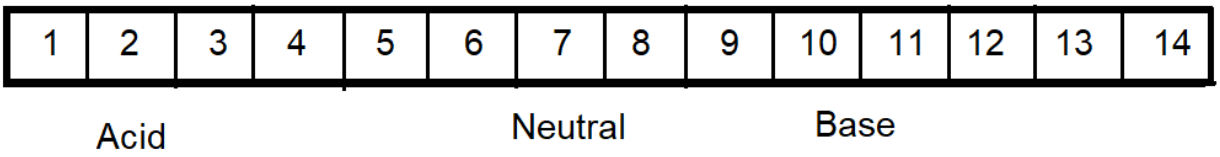
Turns red litmus paper blue
Conducts electricity when dissolved in water
Have a slippery feel
Releases hydroxide (OH^-) ions in water
Reacts with acids in neutralization reactions
Reacts with many oils and fats
Have a pH > 7

pH scale

Scientists often need to know whether a substance is an acid or a base. To do this, they use indicators. An indicator is a substance that changes color at different levels of acidity. Litmus paper is often used as an indicator. Blue litmus paper turns red in the presence of an acid and red litmus paper turns blue in the presence of a base.

Scientists use a scale known as pH scale to indicate the amount of acid or base present in a solution.

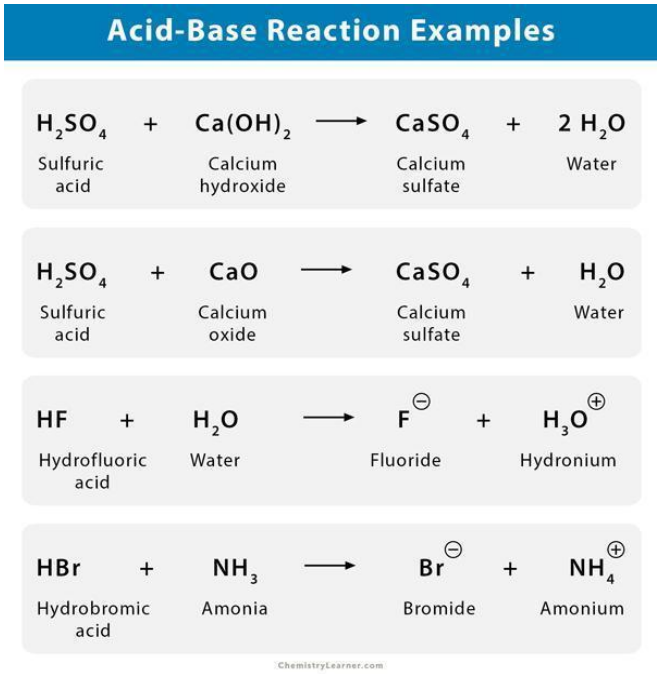
The pH scale goes from 1 to 14



Neutral substances have pH 7. A pH less than 7 is an acid with lower numbers indicating stronger acids. A pH greater than 7 is a base with higher numbers indicating a stronger base.

Acid base reaction

When acids and bases react, they neutralize each other and produce salt and water. This is called *neutralization*. Below are some examples:



Appendix 2: Format of Scientific Experiment Report

A scientific experiment report is a systematic way of communicating the major points of an experiment to other scientists. The report requires clarity and accuracy so that other scientists can check if they can get the same results if they repeat the experiment.

A scientific experiment report can take the format below:

Title

- Precisely identifies the focus of the experiment

Aim

- Concisely states the purpose of the experiment

Method

- Describes what was exactly done and not just what was planned
- Includes:
    - List of materials used
    - Experimental set-up including a diagram
    - Steps used to collect data
    - Any experimental difficulties encountered and how they were resolved or worked around

Results and analysis

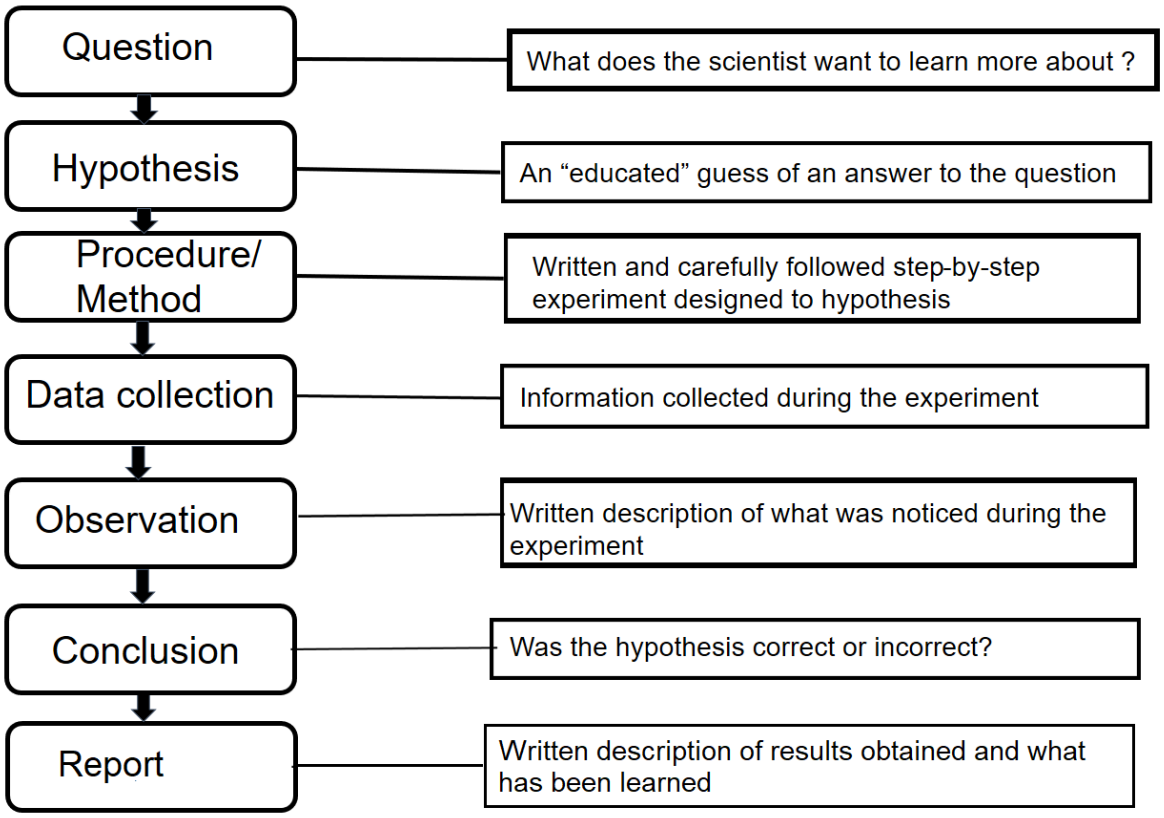
- Presents the main raw data collected during the experiment
- Analysis of raw data

Discussion

- Compares experimental results with predictions
- Identifies how any sources of error might impact on the interpretation of results
- Suggests explanations for unexpected results
- Identifies and comments on any trends observed in the experiment
- Suggests how the experiment could have been involved

Appendix 3: SCIENTIFIC METHOD

The scientific method is a series of steps that scientists use to gather information, improve their knowledge and attempt to explain why and/or how things occur.
The method involves asking questions, making hypotheses, doing an experiment, collecting data, making observations and forming a conclusion.



A written report is a systematic way of communicating the major points of an investigation to other scientists. The report requires clarity and accuracy.

Appendix 4

The reaction of the eggshell in vinegar is an acid-base reaction. When you submerge an egg in vinegar, the shell dissolves, leaving the inner semi-permeable membrane intact.

Vinegar (acid) breaks apart the solid calcium carbonate crystals (base) in the eggshell into their calcium and carbonate parts. The calcium ions stay dissolved in the vinegar (calcium ions are atoms that are missing electrons), while the carbonate goes on to make carbon dioxide — the bubbles that you see.

The acidic vinegar leaves the membrane that lines the inside of the shell intact. Some of the vinegar permeates the membrane due to osmosis, which is why the egg swells. If you shake the egg, you can see the yolk sloshing around in the white. If the membrane tears, the contents will spill out just the same as with any raw egg, only now they have been "pickled" in the vinegar.
Source: https://www.scienceworld.ca/resource/naked-eggs-acid-base-reaction/

Chemical reaction:

The egg shell is composed of calcium carbonate (CaCO3). When calcium carbonate comes in contact with vinegar which contains acetic acid (CH3CO2H) a chemical reaction occurs.

The reaction can be summed up in the following equation:

$$2CH_3COOH + CaCO_3 = H_2O + CO_2 + (CH_3COO)_2Ca.$$

Source:
https://www.scienceofcooking.com/eggs/naked-egg-experiment.html#:~:text=CaCO3(s)%20%2B%202CH3COOH(,they%20are%20held%20tightly%20together).