**STUDENT SHEETS AND TEACHERS GUIDES OF THE SECOND SCHOOL YEAR (2017/2018)**

**MTA-ELTE Research Group on Inquiry-Based Chemistry Education**

**Content Pedagogy Research Program of the Hungarian Academy of Sciences**

It is important to note that the student sheets are not intended to be stand alone. They were used in class with an accompanying dialogue from the teacher. In other words, the teachers talked students through the sheets. Each following student sheet and teacher notes was part of a teacher guide file that contained detailed instructions for teachers how to prepare and guide the students through the activities. Those files are available in Hungarian at the following links:

Student sheet 7: **Jamie Oliver’s perfect salad dressing** [7. feladatlap: Jamie Oliver tökéletes salátaöntete](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBalVFIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--9e7169a0f8432721f9cc9a76ed8b56a5c5185deb/7tokeletes_salatontet2018_07_22vegso.docx?disposition=attachment)

Student sheet 8: **The fight of metals** [8. feladatlap: Fémek harca](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBallFIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--01b015f695004407958ccd2988e4161348efd12e/8femek_harca2018_07_22vegso.docx?disposition=attachment)

Student sheet 9: **How much iron is in the water?** [9. feladatlap: Mennyire vasas az ivóvíz?](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBamNFIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--5b4a30e81884dfb57f9c866ef761f5662fec7483/9vas_ivovizben2018_07_22vegso.docx?disposition=attachment)

Student sheet 10: **The “ancient enemy”** [10. feladatlap: Az "ősi ellenség"](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBamdFIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--792b56d83add0a16a120e0b2cad089134c729608/10vizkemenyseg2018_07_22vegso.docx?disposition=attachment)

Student sheet 11: **Lime in the limelight** [11. feladatlap: Nem ettünk meszet!](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBdXNJIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--681de3345ec077752925d944eb519b20a424d4c1/11Meszko_tojas2018_07_23VEGSOjav2020_01_10.docx?disposition=attachment)

Student sheet 12: **Milk, the complete food** [12. feladatlap: A tej, mint teljes értékű élelmiszer](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBam9FIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--d9f81851dfc8f856ed7d9741cf51f8f70718d88f/12tej2018_07_23vegso.docx?disposition=attachment)

**7. Student sheet: Jamie Oliver’s perfect salad dressing**

(type 1: ‘step-by-step’ version for Group 1 students)

Jamie Oliver, the famous English cook prepares many different salad dressings. He praises the one with sardella paste, and you can watch a video in Hungarian about its preparation on the internet[[1]](#footnote-1). Jamie uses two tablespoons of wine vinegar for this recipe. The characteristic flavours of wine vinegars are due to their different ingredients. (For instance, there is raspberry flavoured vinegar too!) The vinegars made by fermentation contain 3-15% acetic acid in aqueous solutions. If there is not the type of vinegar at home what you would need according to the recipe, it can be replaced with one that has got different concentration, but you will obviously need a different volume of that. However, how do you think the amount of acetic acid in a vinegar is determined? You will get know about it by filling in this worksheet.

**Experiment 1**: Pour a little sodium hydroxide solution into a test tube. Add 1 drop of phenolphthalein solution to it and shake the content of the tube.

**Observation:** After adding the phenolphthalein, the colourless solution became …………………………..…….… colour.

**Explanation:** The phenolphthalein indicates with this colour that the sodium hydroxide solution is ………………….

**Experiment 2**: Pour a little water into a test tube. Add 1 drop of white wine vinegar to it. Add 1 drop of phenolphthalein solution to it and shake the content of the tube.

**Observation:** After adding the phenolphthalein the colour of the solution became ……………………………….…………..

**Explanation:** The acetic acid in the vinegar (white wine vinegar, salad vinegar) is ………………………………………………..

**Experiment 3**: Add sodium hydroxide solution drop-by-drop to the test tube containing the mixture of vinegar solution and phenolphthalein left after finishing the Experiment 2 until the change of colour remains.

**Observation:** The colour of the solution changed from …………………………….. to …………………………………………………..

**Explanation:** The sodium hydroxide (an alkali / a base) reacted with the acetic acid (an acid), while sodium acetate (salt) and water formed: **acid + base = salt + water**. This reaction is called **neutralisation**. After

all the acetic acid had reacted, the excess of the ………………………………………… sodium hydroxide added is indicated

by the …………………………… colour of the phenolphthalein.

**Experiment 4**: There are vinegar solutions in both glasses, labelled “A” and “B”. These were prepared by pouring the same volume of water into both glasses, then adding 1 drop of 6% white wine vinegar into one glass and 2 drops of 6% white wine vinegar into other glass. Determine, **in which of the glasses are the 2 drops of vinegar**! Add 1 drop of phenolphthalein to the content of both glasses. Add sodium hydroxide solution drop-by-drop into the glass labelled “A”, counting the number of drops until the change of colour remains. Stir the solution after adding each drop of sodium hydroxide solution. Then repeat this with the solution being in the glass labelled “B”.

**Observation:** …………. drops of sodium hydroxide solution had to be added to the content of glass labelled “A”

until the changed colour remained. …………. drops of sodium hydroxide solution had to be added to the content of glass labelled “B” until the changed colour remained.

**Explanation:** More acetic acid was in the glass labelled …………., because **more/less sodium hydroxide solution** had to be added until the colour changed. Therefore, the 2 drops of 6% white wine vinegar were in the glass

labelled ………….. Twice as much acetic acid needs …………………………………………….. sodium hydroxide. If the concentration of the sodium hydroxide solution is known, then the concentration of the acetic acid solution can be calculated.

What would you observe, if there were 3 drops of 6% white wine vinegar in a glass, and you would do the Experiment 4 with it?

…………………………………………………………………………………………………………………………………………………………………………….

**7. Student sheet: Jamie Oliver’s perfect salad dressing**

(type 2: ‘step-by-step’ version + explanation of experiment-design for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but after the Experiment 4 the worksheet also contains the text below that the students have to read and discuss with their teacher.*

While doing the Experiment 4, we had to follow **exactly the same process in case of both glasses**:

* the same amount of phenolphthalein was added to both solutions, by the same dropper;
* the same concentration sodium hydroxide solution was added to them, by the same dropper;
* both solutions were stirred after each drop of alkali solution;
* the sodium hydroxide solution was added until the same change of colour.

While designing the experiment, the principle called “**how to vary one thing at a time**” was applied. Only the amount of acetic acid was different in the glasses labelled “A” and “B”, the other parameters were the same. This way, only the different amount of the acetic acid could cause that more drops of sodium hydroxide solutions were needed to reach the same change of colour in the case of the 2 drops of vinegar. Therefore, the **amount of the acetic acid** was **the only changing thing (variable) that was different**. **The needed volume of sodium hydroxide solution only depended** on that, because **the other parameters were held constant**.

**7. Student sheet: Jamie Oliver’s perfect salad dressing**

(type 3: experiment-designing version for Group 3 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), except the Experiment 4 that goes as follows.*

**Experiment 4**: There are vinegar solutions in both glasses, labelled “A” and “B”. These were prepared by pouring the same volume of water into both glasses, then adding 1 drop of 6% white wine vinegar into one glass and 2 drops of 6% white wine vinegar into the other glass. Design an experiment to determine which of the glasses contains the 2 drops of vinegar!

You have to do **exactly the same in the case of both glasses labelled “A” and “B”.** You have to use the **same equipment and materials (solutions)** and accomplish the **same operations** with them. Therefore, while designing the experiment, you apply the principle called “**how to vary one thing at a time**”. If only the **amount of the acetic acid** is different, then this is **the only thing (variable) that changes**, therefore this **causes the different observations in the cases of the two glasses**. All the other **parameters have to be constant**. Based on the Experiment 1-3 **what could be the different observation (experience) that only depends on the amount of acetic acid**?

**Plan of the series of experiments**:………………………………………………………….…………………………….………………………………

…………………………………………………………………………………………………………………………………………………………………………….

…………………………………………………………………………………………………………………………………………………………………………….

**Observations**:……………………………………………………………………………………….……………………………………………………………..

…………………………………………………………………………………………………………………………………………………………………………….

**Explanations**:……………………………………………………………………………………………………………………………………....………………

…………………………………………………………………………………………………………………………………………………………………………….

**7. Student sheet: Jamie Oliver’s perfect salad dressing**

(teacher notes)

Jamie Oliver, the famous English cook prepares many different salad dressings. He praises the one with sardella paste, and you can watch a video in Hungarian about its preparation on the internet[[2]](#footnote-2). Jamie uses two tablespoons of wine vinegar for this recipe. The characteristic flavours of wine vinegars are due to their different ingredients. (For instance, there is raspberry flavoured vinegar too!) The vinegars made by fermentation contain 3-15% acetic acid in aqueous solutions. If there is not the type of vinegar at home what you would need according to the recipe, it can be replaced with one that has got different concentration, but you will obviously need a different volume of that. However, how do you think the amount of acetic acid in a vinegar is determined? You will get know about it by filling in this worksheet.

**Experiment 1**: Pour a little sodium hydroxide solution into a test tube. Add 1 drop of phenolphthalein solution to it and shake the content of the tube.

**Observation:** After adding the phenolphthalein, the colourless solution became ***purple/pink*** colour.

**Explanation:** The phenolphthalein indicates with this colour that the sodium hydroxide solution is ***alkaline****.*

**Experiment 2**: Pour a little water into a test tube. Add 1 drop of white wine vinegar to it. Add 1 drop of phenolphthalein solution to it and shake the content of the tube.

**Observation:** After adding the phenolphthalein the colour of the solution became ***colourless****.*

**Explanation:** The acetic acid in the vinegar (white wine vinegar, salad vinegar) is ***acidic****.*

**Experiment 3**: Add sodium hydroxide solution drop-by-drop to the test tube containing the vinegar solution and the phenolphthalein left after finishing the Experiment 2 until the change of colour remains.

**Observation:** The colour of the solution changed from ***colourless***to ***purple/pink****.*

**Explanation:** The sodium hydroxide (an alkali / a base) reacted with the acetic acid (an acid), while sodium acetate (salt) and water formed: **acid + base = salt + water**. This reaction is called **neutralisation**. After all the acetic acid had reacted, the excess of the ***alkaline*** sodium hydroxide added is indicated by the ***purple/pink*** colour of the phenolphthalein.

**Experiment 4**: [Only for type 1 and 2 student sheets.] There are vinegar solutions in both glasses, labelled “A” and “B”. These were prepared by pouring the same volume of water into both glasses, then adding 1 drop of 6% white wine vinegar into one glass and 2 drops of 6% white wine vinegar into other glass. Determine, **in which of the glasses are the 2 drops of vinegar**! Add 1 drop of phenolphthalein to the content of both glasses. Add sodium hydroxide solution drop-by-drop into the glass labelled “A”, counting the number of drops until the change of colour remains. Stir the solution after adding each drop of sodium hydroxide solution. Then repeat this with the solution being in the glass labelled “B”.

**Observation:** (E.g.) ***16*** drops of sodium hydroxide solution had to be added to the content of glass labelled “A” until the changed colour remained. ***8*** drops of sodium hydroxide solution had to be added to the content of glass labelled “B” until the changed colour remained.

**Explanation:** More acetic acid was in the glass labelled ***„A*”**, because **more/less sodium hydroxide solution** had to be added until the colour changed. Therefore, the 2 drops of 6% white wine vinegar were in the glass labelled ***„A”***. Twice as much acetic acid needs ***twice as much*** sodium hydroxide. If the concentration of the sodium hydroxide solution is known, then the concentration of the acetic acid solution can be calculated.

What would you observe, if there was 3 drops of 6% white wine vinegar in a glass, and you would do the Experiment 4 with it?

***24 drops of sodium hydroxide solution should be added until the changed colour would remain.***

[Only for type 2 student sheets.]

While doing the Experiment 4, we had to follow **exactly the same process in case of both glasses**:

* the same amount of phenolphthalein was added to both solutions, by the same dropper;
* the same concentration sodium hydroxide solution was added to them, by the same dropper;
* both solutions were stirred after each drop of alkali solution;
* the sodium hydroxide solution was added until the same change of colour.

While designing the experiment, the principle called “**how to vary one thing at a time**” was applied. Only the amount of acetic acid was different in the glasses labelled “A” and “B”, the other parameters were the same. This way, only the different amount of the acetic acid could cause that more drops of sodium hydroxide solutions were needed to reach the same change of colour in the case of the 2 drops of vinegar. Therefore, the **amount of the acetic acid** was **the only changing thing (variable) that was different**. **The needed volume of sodium hydroxide solution only depended** on that, because **the other parameters were held constant**.

[Only for type 3 student sheets.]

**Experiment 4**: There are vinegar solutions in both glasses, labelled “A” and “B”. These were prepared by pouring the same volume of water into both glasses, then adding 1 drop of 6% white wine vinegar into one glass and 2 drops of 6% white wine vinegar into the other glass. Design an experiment to determine which of the glasses contains the 2 drops of vinegar!

You have to do **exactly the same in the case of both glasses labelled “A” and “B”.** You have to use the **same equipment and materials (solutions)** and accomplish the **same operations** with them. Therefore, while designing the experiment, you apply the principle called “**how to vary one thing at a time**”. If only the **amount of the acetic acid** is different, then this is **the only thing (variable) that changes**, therefore this **causes the different observations in the cases of the two glasses**. All the other **parameters have to be constant**. Based on the Experiment 1-3 **what could be the different observation (experience) that only depends on the amount of acetic acid**?

**Plan of the series of experiments**: *E.g.:* ***1 drop of phenolphthalein has to be added to the content of both glasses. Sodium hydroxide solution should be added drop-by-drop into the glass labelled “A” until the change of colour remains, counting the number of drops. The solution has to be stirred after adding each drop of sodium hydroxide solution. Then this has to be repeated with the solution being in the glass labelled “B”.***

**Observations**: ***(E.g.) 16 drops of sodium hydroxide solution had to be added to the content of glass labelled “A” until the changed colour remained. 8 drops of sodium hydroxide solution had to be added to the content of glass labelled “B” until the changed colour remained.***

**Explanations**: ***The 2 drops of vinegar were in the*** ***glass labelled “A”, because more sodium hydroxide solution had to be added to that until the changed colour remained***

END OF THE 7. STUDENT SHEETS AND TEACHER NOTES

**8. Student sheet: The fight of metals**

(type 1: ‘step-by-step’ version for Group 1 students)

The alchemists were looking for the “Philosopher's Stone” that you can read about in the “Harry Potter and the Philosopher's Stone” for thousands of years. They were convinced that it could change certain metals to gold. Their belief was fed by the fact that when tools made of iron were left in mine waters containing copper compounds, it looked like the iron would have turned to copper. Nowadays we know that **this was not the case**. Instead, the **iron, being more reactive than the copper, “displaced” the copper in its compounds**. This way the iron got into the solution as a compound and the copper deposited from the solution in form of elemental metal.

So, **metals** can be **arranged in a line**, where the **reactivity decreases into a given direction**. Hydrogen is also a member of this line, because the **elemental hydrogen can also be “displaced” by certain metals** in its compounds. The reactivity line helps us to decide, **which reactions take place and which do not**.

While completing the worksheet, **underline or frame the correct or cross the not correct parts of the text.**

**Experiment 1**: The “Zn team” investigates the reaction of **zinc** with water, the “Mg team” does the same with the **magnesium** and the “Cu team” with the **copper**. First put a piece of metal that you find on your tray into the test tube containing cold water and phenolphthalein, then warm up the content of the tube. Make notes of your observation and share them with the other teams.

**Observations:**

Zn team: The effect of **zinc** (symbol: Zn): the **cold** water containing phenolphthalein became **colourless/pink**.

The effect of **zinc** (symbol: Zn): the **warm** water containing phenolphthalein became **colourless/pink**.

Mg team: The effect of **magnesium** (symbol: Mg): the **cold** water containing phenolphthalein became **colourless/pink**.

The effect of **magnesium** (symbol: Mg): the **warm** water containing phenolphthalein became **colourless/pink**.

Cu team: The effect of **copper** (symbol: Cu): the **cold** water containing phenolphthalein became **colourless/pink**.

The effect of **copper** (symbol: Cu): the **warm** water containing phenolphthalein became **colourless/pink**.

**Explanation:** If a metal **reacts** with water, then the ………………………………….. colour of the phenolphthalein

indicates that the solution formed is …………………………………………...

Zn team: The **zinc** **reacted/did not react** with **cold** water and **reacted/did not react** with **warm** water.

Mg team: The **magnesium** **reacted/did not react** with **cold** water and **reacted/did not react** with **warm** water.

Cu team: The **copper** **reacted/did not react** with **cold** water and **reacted/did not react** with **warm** water.

Write down the equation of the only reaction that took place: ……………………………………………………………………………

**Conclusion:** Among these three metals the …... is more reactive than the …... and the …..... Therefore, in a reactivity line, where the **reactivity decreases from left to right**, this metal is placed **to the left/to the right** from the other two metals.

**Experiment 2**: The “Zn team” investigates the reaction of **zinc** with **hydrochloric acid**, the “Mg team” does the same with the **magnesium** and the “Cu team” with the **copper**. First put a piece of metal that you find on your tray into the test tube containing hydrochloric acid solution (*w*=10%). Make notes of your observation and share them with the other teams.

**Observation:**

Zn team: As an effect of **zinc there was/there was not any fizzing** **in the hydrochloric acid**.

Mg team: As an effect of **magnesium there was/there was not any fizzing** **in the hydrochloric acid**.

Cu team: As an effect of **copper there was/there was not any fizzing** **in the hydrochloric acid**.

**Explanation:**

If a metal **reacts** with hydrochloric acid, then the fizzing shows the development of …………………………………. gas.

Zn team: The **Zn** **reacted/did not react** with hydrochloric acid.

Mg team: The **Mg** **reacted/did not react** with hydrochloric acid.

Cu team: The **Cu** **reacted/did not react** with hydrochloric acid.

Write down the **equations** of the two reactions **that took place** …………………………………………………………………………

…………………………………………………………………………………………………………………………………………………………………………….

**Conclusions:** The …... and the …... replaced the **hydrogen** from its compound (hydrochloric acid), therefore they are **to the left/to the right** from the hydrogen in the reactivity line. The metals that are **to the left/to the right** from the hydrogen in the reactivity line dissolve in dilute acids.

Therefore, the **order of the** **decreasing reactivity** of Zn, Mg, Cu and H is: …… > …… > …… > ……

**Experiment 3**: The “Zn team” investigates the reaction of **zinc,** the “Mg team” the reaction of **magnesium** and the “Cu team” the reaction of **copper** with the solutions of the compounds of the other two metals. Before doing the experiments, **try to predict** which metal will react with which solutions of the compounds of the other metals. Think of the **order of their reactivity** that you determined earlier! Then **put** one piece of metal into each of the solutions of the compounds of the two other metals that you find on your tray. Make notes of your observation and share them with the other teams.

**Observations:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **zinc sulphate solution** | **magnesium chloride solution** | **copper sulphate solution** |
| „Zn team”**zinc** |  | prediction:**react/does not react** | prediction:**react/does not react** |
| observation: | observation: |
| „Mg team”**magnesium** | prediction:**react/does not react** |  | prediction:**react/does not react** |
| observation: | observation: |
| „Cu team**copper** | prediction:**react/does not react** | prediction:**react/does not react** |  |
| observation: | observation: |

**Explanation:** The metal being on the **left** in the line of reactivity **is able/is not able** to react with the ions of the other metals being to the **right** from it.

 **Experiment 4**: We want to decide, whether the **iron (Fe)** is at the place **1.**, place **2.** or place **3.** in the reactivity line seen below.

 K Ca **1.** Mg Al Zn **2.** Co Ni Sn Pb **H** Cu Ag **3.** Au

Step 1: Put one of the iron nails into the hydrochloric acid solution.

Step 2: „Zn team”: Put one of the iron nails into the magnesium chloride solution.

„Mg team” and „Cu team”: Put the other iron nail into the zinc sulphate solution.

**Observation:**

Step 1:………………………………………………………………………………………………………………………………………………………………….

Step 2:………………………………………………………………………………………………………………………………………………………………….

**Explanation:**

Step 1:………………………………………………………………………………………………………………………………………………………………….

Step 2:………………………………………………………………………………………………………………………………………………………………….

Frame the correct answer! The iron (Fe) is at the place **1.**, place **2.** or place **3.** in the reactivity line.

**Homework**

How could you make a crown made of iron look like it was made of gold?

……………………………………………………………………………………………………………………………………………………………………….......

**8. Student sheet: The fight of metals**

(type 2: ‘step-by-step’ version + explanation of experiment-design for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but after the Experiment 4 the worksheet also contains the text below that the students have to read and discuss with their teacher.*

While designing the Experiment 4, we had to **exclude one possibility of the three in both steps**. In this case the **order of the steps could be changed**. (It does not matter, which possibility is excluded first.)

Step 1: Had the iron been at place 3., it could have not reacted with hydrochloric acid, i.e. it could not replace the hydrogen in its compound.

Step 2: Had the iron been at place 1., it would have been more reactive than the magnesium and zinc, i.e. it could have replaced zinc in the zinc sulphate solution and the magnesium in the magnesium chloride solution.

**8. Student sheet: The fight of metals**

(type 3: experiment-designing version for Group 3 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), except the Experiment 4 that goes as follows.*

**Experiment 4**: Design an experiment to determine the place of the **iron (Fe)** in the line of reactivity of metals. Whether the **iron (Fe)** is at the place **1.**, place **2.** or place **3.** in the reactivity line seen below? 2 iron nails, 2 empty test tubes, dilute hydrochloric acid solution and the solutions of metal compounds that you have used for the previous experiments are available.

 K Ca **1.** Mg Al Zn **2.** Co Ni Sn Pb **H** Cu Ag **3.** Au

You have 2 iron nails and 2 test tubes. Therefore you have to determine the place of the iron in **2 steps**. You have to **exclude one possibility of the 3** by both steps. Can you **design steps** by that you can decide whether the iron is in front of the magnesium, zinc, hydrogen or copper, or after them in the reactivity line? Is the **order of the steps** important or they are **exchangeable**? Describe the plan of the 2 steps, then do them and draw the conclusions.

**Plan of the of experiments**:

Step 1: …………………………………………………………………………………………………………………………………………………………………

Step 2: ………………………………………………………………………………………………………………………………………………………………

**Observations**:

Step 1: …………………………………………………………………………………………………………………………………………………………………

Step 2: ………………………………………………………………………………………………………………………………………………………………

**Explanations**:

Step 1: …………………………………………………………………………………………………………………………………………………………………

Step 2: ………………………………………………………………………………………………………………………………………………………………

Frame the correct answer! The iron (Fe) is at the place **1.**, place **2.** or place **3.** in the reactivity line.

**8. Student sheet: The fight of metals**

(teacher notes)

The alchemists were looking for the “Philosopher's Stone” that you can read about in the “Harry Potter and the Philosopher's Stone” for thousands of years. They were convinced that it could change certain metals to gold. Their belief was fed by the fact that when tools made of iron were left in mine waters containing copper compounds, it looked like the iron would have turned to copper. Nowadays we know that **this was not the case**. Instead, the **iron, being more reactive than the copper, “displaced” the copper in its compounds**. This way the iron got into the solution as a compound and the copper deposited from the solution in form of elemental metal.

So, **metals** can be **arranged in a line**, where the **reactivity decreases into a given direction**. Hydrogen is also a member of this line, because the **elemental hydrogen can also be “displaced” by certain metals** in its compounds. The reactivity line helps us to decide, **which reactions take place and which do not**.

While completing the worksheet, **underline or frame the correct or cross the not correct parts of the text.**

**Experiment 1**: The “Zn team” investigates the reaction of **zinc** with water, the “Mg team” does the same with the **magnesium** and the “Cu team” with the **copper**. First put a piece of metal that you find on your tray into the test tube containing cold water and phenolphthalein, then warm up the content of the tube. Make notes of your observation and share them with the other teams.

**Observations:**

Zn team: The effect of **zinc** (symbol: Zn): the **cold** water containing phenolphthalein became **colourless/pink**.

The effect of **zinc** (symbol: Zn): the **warm** water containing phenolphthalein became **colourless/pink**.

Mg team: The effect of **magnesium** (symbol: Mg): the **cold** water containing phenolphthalein became **colourless/pink**.

The effect of **magnesium** (symbol: Mg): the **warm** water containing phenolphthalein became **colourless**/**pink**.

Cu team: The effect of **copper** (symbol: Cu): the **cold** water containing phenolphthalein became **colourless/pink**.

The effect of **copper** (symbol: Cu): the **warm** water containing phenolphthalein became **colourless/pink**.

**Explanation:** If a metal **reacts** with water, then the ***purple/pink*** colour of the phenolphthalein

indicates that the solution formed is ***alkaline.***

Zn team: The **zinc** **reacted**/**did not react** with **cold** water and **reacted**/**did not react** with **warm** water.

Mg team: The **magnesium** **reacted**/**did not react** with **cold** water and **reacted/did not react** with **warm** water.

Cu team: The **copper** **reacted**/**did not react** with **cold** water and **reacted**/**did not react** with **warm** water.

Write down the equation of the only reaction that took place: ***Mg + 2 H2O → Mg(OH)2 + H2***

**Conclusion:** Among these three metals the ***Mg*** is more reactive than the ***Zn*** and the ***Cu***. Therefore, in a reactivity line, where the **reactivity decreases from left to right**, this metal is placed **to the left/to the right** from the other two metals.

**Experiment 2**: The “Zn team” investigates the reaction of **zinc** with **hydrochloric acid**, the “Mg team” does the same with the **magnesium** and the “Cu team” with the **copper**. First put a piece of metal that you find on your tray into the test tube containing hydrochloric acid solution (*w*=10%). Make notes of your observation and share them with the other teams.

**Observation:**

Zn team: As an effect of **zinc there was/there was not** **any fizzing** **in the hydrochloric acid**.

Mg team: As an effect of **magnesium there was/there was not** **any fizzing** **in the hydrochloric acid**.

Cu team: As an effect of **copper there was/there was not any fizzing** **in the hydrochloric acid**.

**Explanation:**

If a metal **reacts** with hydrochloric acid, then the fizzing shows the development of ***hydrogen***gas.

Zn team: The **Zn** **reacted/did not react** with hydrochloric acid.

Mg team: The **Mg** **reacted/did not react** with hydrochloric acid.

Cu team: The **Cu** **reacted/did not react** with hydrochloric acid.

Write down the **equations** of the two reactions **that took place**:

 ***Zn + 2 HCl → ZnCl2 + H2 Mg + 2 HCl → MgCl2 + H2***

**Conclusions:** The ***Zn*** and the ***Mg*** replaced the **hydrogen** from its compound (hydrochloric acid), therefore they are **to the left/to the right** from the hydrogen in the reactivity line. The metals that are **to the left/to the right** from the hydrogen in the reactivity line dissolve in dilute acids.

Therefore, the **order of the** **decreasing reactivity** of Zn, Mg, Cu and H is: ***Mg*** *>* ***Zn*** *>* ***H*** *>* ***Cu***

**Experiment 3**: The “Zn team” investigates the reaction of **zinc,** the “Mg team” the reaction of **magnesium** and the “Cu team” the reaction of **copper** with the solutions of the compounds of the other two metals. Before doing the experiments, **try to predict** which metal will react with which solutions of the compounds of the other metals. Think of the **order of their reactivity** that you determined earlier! Then **put** one piece of metal into each of the solutions of the compounds of the two other metals that you find on your tray. Make notes of your observation and share them with the other teams.

**Observations:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **zinc sulphate solution** | **magnesium chloride solution** | **copper sulphate solution** |
| „Zn team”**zinc** |  | prediction:**react**/**does not react**  | prediction:**react/does not react** |
| observation: ***there is no change*** | observation: ***red deposit on the surface of the metal*** |
| „Mg team”**magnesium** | prediction:**react/does not react**  |  | prediction:**react/does not react**  |
| observation: ***dark deposit on the surface of the metal*** | observation: ***red deposit on the surface of the metal*** |
| „Cu team**copper** | prediction:**react**/**does not react** | prediction:**react**/**does not react**  |  |
| observation:***there is no change***  | observation:***there is no change***  |

**Explanation:** The metal being on the **left** in the line of reactivity **is able/is not able** to react with the ions of the other metals being to the **right** from it.

**Experiment 4**: [Only for type 1 and 2 student sheets.]

We want to decide, whether the **iron (Fe)** is at the place **1.**, place **2.** or place **3.** in the reactivity line seen below.

 K Ca **1.** Mg Al Zn **2.** Co Ni Sn Pb **H** Cu Ag **3.** Au

Step 1: Put one of the iron nails into the hydrochloric acid solution.

Step 2: „Zn team”: Put one of the iron nails into the magnesium chloride solution.

„Mg team” and „Cu team”: Put the other iron nail into the zinc sulphate solution.

**Observation:**

Step 1: ***A fizzing started.***

Step 2: „Zn team”: **There was not any noticeable change.**

„Mg team” and „Cu team”: ***There was not any noticeable change.***

**Explanation:**

Step 1: ***The iron replaced the hydrogen from its compound (the hydrochloric acid), therefore it is on the left of the hydrogen in the reactivity line****.*

Step 2:

***The iron is less reactive than the magnesium, therefore it is on the right of the magnesium in the reactivity line.***

***The iron is less reactive than the zinc, therefore it is on the right of the zinc in the reactivity line.***

Frame the correct answer! The iron (Fe) is at the place **1.**, place **2.** or place **3.** in the reactivity line.

**Homework**

How could you make a crown made of iron look like it was made of gold?

***It has to be put in a solution of a gold compound.***

[Only for type 2 student sheets.]

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but after the Experiment 4 the worksheet also contains the text below that the students have to read and discuss with their teacher.*

While designing the Experiment 4, we had to **exclude one possibility of the three in both steps**. In this case the **order of the steps could be changed**. (It does not matter, which possibility is excluded first.)

Step 1: Had the iron been at place 3., it could have not reacted with hydrochloric acid, i.e. it could not replace the hydrogen in its compound.

Step 2: Had the iron been at place 1., it would have been more reactive than the magnesium and zinc, i.e. it could have replaced zinc in the zinc sulphate solution and the magnesium in the magnesium chloride solution.

[Only for type 3 student sheets.]

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), except the Experiment 4 that goes as follows.*

**Experiment 4**: Design an experiment to determine the place of the **iron (Fe)** in the line of reactivity of metals. Whether the **iron (Fe)** is at the place **1.**, place **2.** or place **3.** in the reactivity line seen below? 2 iron nails, 2 empty test tubes, dilute hydrochloric acid solution and the solutions of metal compounds that you have used for the previous experiments are available.

 K Ca **1.** Mg Al Zn **2.** Co Ni Sn Pb **H** Cu Ag **3.** Au

You have 2 iron nails and 2 test tubes. Therefore you have to determine the place of the iron in **2 steps**. You have to **exclude one possibility of the 3** by both steps. Can you **design steps** by that you can decide whether the iron is in front of the magnesium, zinc, hydrogen or copper, or after them in the reactivity line? Is the **order of the steps** important or they are **exchangeable**? Describe the plan of the 2 steps, then do them and draw the conclusions.

**Plan of the of experiments**:

Step 1:

***1.1.******Alternative: One of the iron nails has to be put into one of the test tubes and we have to pour hydrochloric acid on it. With this step it can be determined, whether the place 3. is right or not.***

***1.2.******Alternative: One of the iron nails has to be put into one of the test tubes and we have to pour copper sulphate solution on it. With this step it can be determined, whether the place 3. is right or not.***

Step 2:

“Zn team”

***2.1.******Alternative: One of the iron nails has to be put into the other test tubes and we have to pour magnesium chloride solution on it. With this step it can be determined, whether the place 1. or 2. is right.***

***2.2.******Alternative: One of the iron nails has to be put into the other test tubes and we have to pour water + phenolphthalein on it. With this step it can be determined, whether the place 1. or 2. is right.***

“Mg team” and “Cu team”

***2.1.******Alternative: One of the iron nails has to be put into the other test tubes and we have to pour zinc sulphate solution on it. With this step it can be determined, whether the place 1. or 2. is right.***

***2.2.******Alternative: One of the iron nails has to be put into the other test tubes and we have to pour water + phenolphthalein on it. With this step it can be determined, whether the place 1. or 2. is right.***

**Observations**:

Step 1:

***1.1.******Alternative: A fizzing started.***

***1.2.******Alternative: Red deposit on the surface of the metal.***

Step 2:

„Zn team”:

***2.1.******Alternative: There was not any noticeable change.***

***2.2.******Alternative: There was not any noticeable change (neither in cold, nor in hot water).***

„Mg team” and „Cu team”:

***2.1.******Alternative: There was not any noticeable change.***

***2.2.******Alternative: There was not any noticeable change (neither in cold, nor in hot water).***

**Explanation:**

Step 1:

***1.1.******Alternative: The iron replaced the hydrogen from its compound (the hydrochloric acid), therefore it is on the left of the hydrogen in the reactivity line. So, the iron is on place 1. or place 2.***

***1.2.******Alternative: The iron replaced the copper from its compound (the copper sulphate), therefore it is on the left of the copper in the reactivity line. So, the iron is on place 1. or place 2.***

Step 2:

“Zn team”

***2.1.******Alternative: The iron is less reactive than the magnesium, therefore it is on the right of the magnesium in the reactivity line. So, the iron is at place 2.***

***2.2.******Alternative: The iron is less reactive than the magnesium, therefore it is on the right of the magnesium in the reactivity line. So, the iron is at place 2.***

 “Mg team” and “Cu team”

***2.1.******Alternative: The iron is less reactive than the zinc, therefore it is on the left of the zinc in the reactivity line. So, the iron is on place 2.***

***2.2.******Alternative: The iron is less reactive than the magnesium, therefore it is on the left of the magnesium in the reactivity line. So, the iron is on place 2.***

Frame the correct answer! The iron (Fe) is at the place **1.**, place **2.** or place **3.** in the reactivity line.

END OF THE 8. STUDENT SHEETS AND TEACHER NOTES

**9. Student sheet: How much iron is in the water?**

(type 1: ‘step-by-step’ version for Group 1 students)

The **quality of the drinking water is controlled according to strict standards** in our country. (Therefore, it is entirely unnecessary to buy water purifying machines for home or to drink bottled water.) If any of the concentration of the constituents of the water sample exceeds the limit given by the standards, then the **authorities claim that the water is unsuitable for human consumption**. The iron ions are not dangerous to our health, but their concentration must not be more than 200 µg/litre (i.e. 0.200 mg/dm3), because they influence the taste of the water. This student sheet deals with the determination of the concentration of the iron(III) ions.

**EACH PASTEUR PIPETTE SHOULD BE PUT BACK INTO THE SOLUTION THAT HAS BEEN MEASURED WITH IT!**

While completing the worksheet, **underline or frame the correct or cross the not correct parts of the text.**

**Experiment 1**: The concentration of the iron (III) ion solution („Fe3+ solution”) is 0.050 mg Fe3+/cm3. This means that there is 0.050 mg Fe3+ in 1 cm3 solution. Measure 9 cm3 of the iron (III) ion solution into the test tube “**9**” by the measuring cylinder. (The level of the liquid in the measuring cylinder can be most easily adjusted by using the Pasteur pipette.) Add 1 cm3 potassium thiocyanate solution (“KSCN solution”) to it by the other Pasteur pipette, then homogenise the content of the test tube.

**Observation:** The colour of the solution became …………………………..…….….

**Explanation:** The iron (III) ions (Fe3+) form a compound with the thiocyanate ions (SCN-) that has got this colour.

**Experiment 2**: Measure 1 cm3 of the iron (III) ion solution into the test tube “**1**”. Add 8 cm3 distilled water. Add 1 cm3 potassium thiocyanate solution (“KSCN solution”) to it then homogenise the content of the test tube.

**Observation:** The colour of the solution became …………………………..…….….

**Explanation:** The solution in the test tube “1” is **more dilute/more concentrated** than the solution in the test tube “9”. Therefore, the shade of the colour of the solution in the test tube “1” is **lighter/darker** than the shade of the colour of the solution in the test tube “9”.

**Experiment 3**: Prepare the following solution in the test tubes „3”, „5” and „7”. (The final volume is 10 cm3 in each case.)

test tube „3”: 3 cm3 iron (III) ion solution + 6 cm3 distilled water + 1 cm3 KSCN solution;

test tube „5”: 5 cm3 iron (III) ion solution + 4 cm3 distilled water + 1 cm3 KSCN solution;

test tube „7”: 7 cm3 iron (III) ion solution + 2 cm3 distilled water + 1 cm3 KSCN solution;

**Observation:** The higher the concentration of the iron (III) ions in the solution, the **lighter/darker** is the shade of its colour.

**Explanation: The higher the concentration of the iron (III) ions in the solution, the less/more coloured compound forms of them.[[3]](#footnote-3)**

**Experiment 4**: There is 9 cm3 iron (III) ion solution with **unknown concentration** in the test tube “X”. Add 1 cm3 potassium thiocyanate solution (“KSCN solution”) to it then homogenise the content of the test tube. Determine the concentration of the iron (III) ions in this solution. Compare the colour of the solution to the colour of the solutions in the other test tubes.

**Observation:** The colour of the solution in the test tube “X” is the most similar to the colour of the solution in

the test tube ……. OR: The colour of the solution in the test tube “X” is between the colours of the solutions in

the test tube ……. and the test tube …….

**Explanation:** There was about…….. cm3 of the iron (III) ion solution with the concentration of 0.050 mg/cm3 in

the test tube “X”. The iron (III) ion content of the solution after adding the KSCN solution is …….. mg/10 cm3, i.e.

about ……. mg/dm3. This is **more dilute/more concentrated** than the limit in the standard. The water sample containing iron (III) ion in this concentration is **suitable/ not suitable** for human consumption.

**In the reality,** the iron (III) content of the water samples is determined by applying this principle, but **using more precise equipment** and **sensitive instruments.** Then the shades of the colour of the solutions can be compared at much lower concentrations.

**9. Student sheet: How much iron is in the water?**

(type 2: ‘step-by-step’ version + explanation of experiment-design for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but after the Experiment 4 the worksheet also contains the text below that the students have to read and discuss with their teacher.*

While designing the experiment, the principle called “**how to vary one thing at a time**” was applied:

* the same volume and concentration KSCN solution was added to each solution;
* the final volume of the solutions was always 10 cm3 (together with the added distilled water when it was necessary).

The only **variable** **that changed** was the **iron (III) ion concentration** of the solutions. The **shade** (**intensity) of the colour depended** on that, because it is **in proportion** with the iron (III) ion concentration of the solution. The intensity of the colour of the solution with **unknown concentration** **was compared** to the intensity of the colour of the solutions with **known concentration**. By doing this, we could **conclude** the iron (III) ion concentration of the solution. This method can be used **in general** too, if **a property of a solution is in proportion with its concentration**. At these times **a series of the solutions with known concentration** has to be prepared (“calibration series”). Comparing the property of the solution with unknown concentration to that of the series of the solutions, the concentration of the unknown solution can be worked out. **In the reality,** the iron (III) content of the water samples is determined by applying this principle, but **using more precise equipment** and **sensitive instruments.** Then the shades of the colour of the solutions can be compared at much lower concentrations.

**9. Student sheet: How much iron is in the water?**

(type 3: experiment-designing version for Group 3 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), until the end of the Experiment 3 and after that goes as follows.*

**Experiment 3**: There is iron (III) ion solution with unknown concentration in the test tube “X”. Determine, **about how many cm3** **of the iron (III) ion solution with the concentration of 0.050 mg/cm3 was put in this test tube** before it was diluted by distilled water to 9 cm3. Design the experiment, keeping in mind that you have got **3 empty test tubes**.

While designing the experiment, you have to apply the principle called “**how to vary one thing at a time**”. Therefore, you have to do **everything in the same way**. The same **equipment** and **materials** (solutions) have to be used and you have to do the same **operations**. If only the content of the iron (III) ions is different in the test tubes (this is the **only thing/variable** **that changes**), then **only this can cause the different observations**.

**Plan of the series of experiments**:………………………………………………………….…………………………….………………………………

…………………………………………………………………………………………………………………………………………………………………………….

…………………………………………………………………………………………………………………………………………………………………………….

…………………………………………………………………………………………………………………………………………………………………………….

**Observations**:……………………………………………………………………………………….……………………………………………………………..

…………………………………………………………………………………………………………………………………………………………………………….

**Explanations**: There was **about …….. cm3** of the iron (III) ion solution with the concentration of 0.050 mg/cm3 in

the test tube “X”. The iron (III) ion content of the solution after adding the KSCN solution is …….. mg/10 cm3, i.e.

about ……. mg/dm3. This is **more dilute/more concentrated** than the limit in the standard. The water sample containing iron (III) ion in this concentration is **suitable/unsuitable** for human consumption.

This **method** applied for doing these experiments can be used **in general** too, if **a property of a solution is in proportion with its concentration**. At these times **a series of the solutions with known concentration** has to be prepared (“calibration series”). Comparing the property of the solution with **unknown concentration** **to that of the series of the solutions, the concentration of the unknown solution can be worked out**. **In the reality,** the iron (III) content of the water samples is determined by applying this principle, but **using more precise equipment** and **sensitive instruments.** Then the shades of the colour of the solutions can be compared at much lower concentrations.

**9. Student sheet: How much iron is in the water?**

(teacher notes)

The **quality of the drinking water is controlled according to strict standards** in our country. (Therefore, it is entirely unnecessary to buy water purifying machines for home or to drink bottled water.) If any of the concentration of the constituents of the water sample exceeds the limit given by the standards, then the **authorities claim that the water is unsuitable for human consumption**. The iron ions are not dangerous to our health, but their concentration must not be more than 200 µg/litre (i.e. 0.200 mg/dm3), because they influence the taste of the water. This student sheet deals with the determination of the concentration of the iron (III) ions.

**EACH PASTEUR PIPETTE SHOULD BE PUT BACK INTO THE SOLUTION THAT HAS BEEN MEASURED WITH IT!**

While completing the worksheet, **underline or frame the correct or cross the not correct parts of the text.**

**Experiment 1**: The concentration of the iron (III) ion solution („Fe3+ solution”) is 0.050 mg Fe3+/cm3. This means that there is 0.050 mg Fe3+ in 1 cm3 solution. Measure 9 cm3 of the iron (III) ion solution into the test tube “**9**” by the measuring cylinder. (The level of the liquid in the measuring cylinder can be most easily adjusted by using the Pasteur pipette.) Add 1 cm3 potassium thiocyanate solution (“KSCN solution”) to it by the other Pasteur pipette, then homogenise the content of the test tube.

**Observation:** The colour of the solution became ***deep*** ***red***.

**Explanation:** The iron (III) ions (Fe3+) form a compound with the thiocyanate ions (SCN-) that has got this colour.

**Experiment 2**: Measure 1 cm3 of the iron (III) ion solution into the test tube “**1**”. Add 8 cm3 distilled water. Add 1 cm3 potassium thiocyanate solution (“KSCN solution”) to it then homogenise the content of the test tube.

**Observation:** The colour of the solution became ***pale******red****.*

**Explanation:** The solution in the test tube “1” is **more dilute/more concentrated** than the solution in the test tube “9”. Therefore, the shade of the colour of the solution in the test tube “1” is **lighter/darker** than the shade of the colour of the solution in the test tube “9”.

[Only for type 1 and type 2 student sheets.]

**Experiment 3**: Prepare the following solution in the test tubes „3”, „5” and „7”. (The final volume is 10 cm3 in each case.)

test tube „3”: 3 cm3 iron (III) ion solution + 6 cm3 distilled water + 1 cm3 KSCN solution;

test tube „5”: 5 cm3 iron (III) ion solution + 4 cm3 distilled water + 1 cm3 KSCN solution;

test tube „7”: 7 cm3 iron (III) ion solution + 2 cm3 distilled water + 1 cm3 KSCN solution;

**Observation:** The higher the concentration of the iron (III) ions in the solution, the **lighter/darker** is the shade of its colour.

**Explanation: The higher the concentration of the iron (III) ions in the solution, the less/more coloured compound forms of them.[[4]](#footnote-4)**

**Experiment 4**: There is 9 cm3 iron (III) ion solution with **unknown concentration** in the test tube “X”. Add 1 cm3 potassium thiocyanate solution (“KSCN solution”) to it then homogenise the content of the test tube. Determine the concentration of the iron (III) ions in this solution. Compare the colour of the solution to the colour of the solutions in the other test tubes.

**Observation:** The colour of the solution in the test tube “X” is the most similar to the colour of the solution in the test tube ***(e.g.) “5”.*** OR: The colour of the solution in the test tube “X” is between the colours of the solutions in the test tube ***(e.g.) “1”*** and the test tube ***“3”***

**Explanation:** There was about ***(e.g.) “5”*** cm3 of the iron(III) ion solution with the concentration of 0,050 mg/cm3 in the test tube “X”. The iron(III) ion content of the solution after adding the KSCN solution is ***(e.g.) 0,25*** mg/10 cm3, i.e. about ***(e.g.) 25*** mg/dm3. This is **more dilute/more concentrated** than the limit in the standard. The water sample containing iron(III) ion in this concentration is **suitable/not suitable** for human consumption.

**In the reality,** the iron (III) content of the water samples is determined by applying this principle, but **using more precise equipment** and **sensitive instruments.** Then the shades of the colour of the solutions can be compared at much lower concentrations.

[Only for type 2 student sheets.]

While designing the experiment, the principle called “**how to vary one thing at a time**” was applied:

* the same volume and concentration KSCN solution was added to each solution;
* the final volume of the solutions was always 10 cm3 (together with the added distilled water when it was necessary).

The only **variable** **that changed** was the **iron (III) ion concentration** of the solutions. The **shade** (**intensity) of the colour depended** on that, because it is **in proportion** with the iron (III) ion concentration of the solution. The intensity of the colour of the solution with **unknown concentration** **was compared** to the intensity of the colour of the solutions with **known concentration**. By doing this, we could **conclude** the iron (III) ion concentration of the solution. This method can be used **in general** too, if **a property of a solution is in proportion with its concentration**. At these times **a series of the solutions with known concentration** has to be prepared (“calibration series”). Comparing the property of the solution with unknown concentration to that of the series of the solutions, the concentration of the unknown solution can be worked out. **In the reality,** the iron (III) content of the water samples is determined by applying this principle, but **using more precise equipment** and **sensitive instruments.** Then the shades of the colour of the solutions can be compared at much lower concentrations.

[Only for type 3 student sheets.]

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), until the end of the Experiment 3 and after that goes as follows.*

**Experiment 3**: There is iron (III) ion solution with unknown concentration in the test tube “X”. Determine, **about how many cm3** **of the iron (III) ion solution with the concentration of 0.050 mg/cm3 was put in this test tube** before it was diluted by distilled water to 9 cm3. Design the experiment, keeping in mind that you have got **3 empty test tubes**.

While designing the experiment, you have to apply the principle called “**how to vary one thing at a time**”. Therefore, you have to do **everything in the same way**. The same **equipment** and **materials** (solutions) have to be used and you have to do the same **operations**. If only the content of the iron (III) ions is different in the test tubes (this is the **only thing/variable** **that changes**), then **only this can cause the different observations**.

**Plan of the series of experiments**: ***First there should be iron (III) ions solutions prepared in the other three test tubes, following the same procedure given above in the case of test tube „1” and „9”. E.g.:***

***test tube „3”: 3 cm3 iron (III) ion solution + 6 cm3 distilled water + 1 cm3 KSCN solution;***

***test tube „5”: 5 cm3 iron (III) ion solution + 4 cm3 distilled water + 1 cm3 KSCN solution;***

***test tube „7”: 7 cm3 iron (III) ion solution + 2 cm3 distilled water + 1 cm3 KSCN solution;***

***Then 1 cm3 KSCN solution should be added to the iron (III) ion solution with unknown concentration. The colour of that solution should be compared with colours of the series of solutions that we got in the experiments before. We have to find which has got the same colour, or to which colour it resembles the most.***

**Observations**: ***The more concentrated the solution, the more intensive is its colour. The colour of the solution in the test tube “X” is the most similar to the colour of the solution in the test tube (e.g.) “5”. OR: The colour of the solution in the test tube “X” is between the colours of the solutions in the test tube (e.g.) “1” and the test tube “3”***

**Explanations**: There was about ***(e.g.) “5”*** cm3 of the iron(III) ion solution with the concentration of 0,050 mg/cm3 in the test tube “X”. The iron(III) ion content of the solution after adding the KSCN solution is ***(e.g.) 0,25*** mg/10 cm3, i.e. about ***(e.g.) 25*** mg/dm3. This is **more dilute/more concentrated** than the limit in the standard. The water sample containing iron(III) ion in this concentration is **suitable/not suitable** for human consumption.

This **method** applied for doing these experiments can be used **in general** too, if **a property of a solution is in proportion with its concentration**. At these times **a series of the solutions with known concentration** has to be prepared (“calibration series”). Comparing the property of the solution with **unknown concentration** **to that of the series of the solutions, the concentration of the unknown solution can be worked out**. **In the reality,** the iron (III) content of the water samples is determined by applying this principle, but **using more precise equipment** and **sensitive instruments.** Then the shades of the colour of the solutions can be compared at much lower concentrations.

END OF THE 9. STUDENT SHEETS AND TEACHER NOTES

**10. Student sheet: The “ancient enemy”**

(type 1: ‘step-by-step’ version for Group 1 students)

We can often see housewives and plumbers fighting against the effect of **limescale** in the advertisements. The limescale deposited from **hard water** is not only **ugly**, but it is also **damaging** and **dangerous**. It increases the energy necessary to boil the water, due to its **heat insulation** effect, and it can even cause furnace explosion. The **soap does not form enough foam in the hard water**, its cleaning effect is reduced and even grey scum is formed. Therefore, **water softening** is important for the households and for the industry. This fact is exploited by the **cheaters** who want to sell the **pseudoscientific** “electric limescale preventer” and who call the limescale an “ancient enemy”. However, themselves are the “ancient enemy” who live of the ignorant people money…

Now we will investigate how the **water softening can be done in a really effective way**. First we have to find out **which cations cause the hardness of the water**. The following 4 cations are the most abundant in the natural waters, usually in the following order of their decreasing concentration: Ca2+> Mg2+> Na+> K+. In Experiment 1 you will investigate the effects of the four cations. (Anions do not cause water hardness.)

**Experiment 1**: There is 5 cm3 distilled water in the test tube 1 that you find on your tray. There is a solution of the compound (chloride) of the cation in the test tube 2 that your team will examine. Add 1 cm3 soap solution into both test tubes. Use the stoppers to close both test tubes and shake them ten times with the same intensity. Measure the height of the foam by the ruler in both test tubes and write the data in the table below. Then write the data of the other teams into the table and draw a conclusion.

While completing the worksheet, **underline or frame the correct or cross the not correct parts of the text.**

|  |  |  |
| --- | --- | --- |
| Teams | **Observations:** Height of the foam (cm) | **Conclusions/Explanations:** |
| in distilled water | in the salt solutions |
| Teams A)  |  | CaCl2 solution: | Ca2+ **causes/does not cause** hardness. |
| Teams B) |  | MgCl2 solution: | Mg2+ **causes/does not cause** hardness. |
| Teams C) |  | NaCl solution: | Na+ **causes/does not cause** hardness. |
| Teams D) |  | KCl solution: | K+ **causes/does not cause** hardness. |

At the time of the **softening procedure**, the …………………………………………. ions causing the hardness should be removed from the water. This could be done by **physical** and **chemical** methods. The **distilled water** is purified by a **physical** method. This could be bought, but it is too **expensive** to use it for instance for washing. Which **different physical property** of the water and its solutes (salts) is exploited at the time of **distillation**?

……………………………………………………………………………………………… Why do you think the distilled water is expensive?

…………………………………………………………………………………………………………………………………………………………………………….

**Water softeners** can be used for softening the water by **chemical** methods. These remove the ions causing the hardness by forming a **precipitate** with them (**that are hardly soluble in water**). In the Experiment 2 you will examine whether the **washing soda** (Na2CO3) and the **trisodium phosphate** (Na3PO4) that are suggested water softeners have really got that **softening** effect. The hard water will be **modelled** by CaCl2 solution and MgCl2 solution, whereas the softeners with sodium carbonate (Na2CO3) and trisodium phosphate (Na3PO4). The four different types of teams will try the 4 different possible combinations.

**Experiment 2**:

a) There are 5 cm3 solution in both the test tube 3 and test tube 4 on your tray. In the test tube 3 there is CaCl2 solution for teams A) and teams B), and MgCl2 solution for teams C) and teams D). In the test tube 4 there is washing soda solution for teams A) and teams C), and trisodium phosphate solution for teams B) and teams D) that are concentrated enough to form a precipitate with all the calcium ions or magnesium ions. Pour all the liquid **from the test tube 4 to the test tube 3.**

Write down the **observations** of all the four types of teams into the following table, finish and balance the **equations** together. Underline the **formulae of the precipitates** formed **in the reaction equations**.

|  |  |  |  |
| --- | --- | --- | --- |
| Teams | The mixed solutions | **Observations:** | **Explanations: (with reaction equations):** |
| Teams A)  | CaCl2 solution + Na2CO3 solution (washing soda) |  | CaCl2 + Na2CO3 =  |
| Teams B) | CaCl2 solution + Na3PO4- solution (trisodium phosphate) |  | CaCl2 + Na3PO4 = |
| Teams C) | MgCl2 solution + Na2CO3 solution (washing soda) |  | MgCl2 + Na2CO3 = |
| Teams D) | MgCl2 solution + Na3PO4 solution (trisodium phosphate) |  | MgCl2 + Na3PO4 =  |

b) Using a funnel and filter paper filter the content of the **test tube 3 into the test tube 4** (in that the washing soda or the trisodium phosphate had been). Measure 5 cm3 of the filtrate into the test tube 5 and add 1 cm3 soap solution. Use the stoppers to close the test tube and shake it ten times. Measure the height of the foam by the ruler and write the data in the table below. Compare these with the observations of the Experiment 1 and draw a conclusion.

|  |  |  |  |
| --- | --- | --- | --- |
| Teams | The filtrate of the mixed solutions + soap solution | **Observations:** Height of the foam (cm) | **Conclusions/Explanations:** |
| Teams A)  | CaCl2 solution + Na2CO3 solution + soap solution |  | Na2CO3 solution (washing soda) **is suitable / is not suitable** as a water softener. |
| Teams B) | CaCl2 solution + Na3PO4- solution + soap solution |  | Na3PO4 solution (trisodium phosphate) **is suitable / is not suitable** as a water softener. |
| Teams C) | MgCl2 solution + Na2CO3 solution + soap solution |  | Na2CO3 solution (washing soda) **is suitable / is not suitable** as a water softener. |
| Teams D) | MgCl2 solution + Na3PO4 solution + soap solution |  | Na3PO4 solution (trisodium phosphate) **is suitable / is not suitable** as a water softener. |

Which of the washing soda and the trisodium phosphate causes more harmful environmental pollution and why?

…………………………………………………………………………………………………………………………………………………………………………….

The **phosphate free washing powders** contain active ingredients that are not sensitive to the hardness of water. There are also substances in them that reduce the hardness of water (e.g. zeolite that exchange the ions causing hardness to other ions).

**10. Student sheet: The “ancient enemy”**

(type 2: ‘step-by-step’ version + explanation of experiment-design for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but after the table of the Experiment 2.b the worksheet also contains the text and the table below that the students have to read and discuss with their teacher.*

Now, let us have a look, how we could have worked out knowing the **table below** that shows the **solubility of salts in water, which compounds are suitable water softeners** and how this experiment could have been **designed**. By using this table we apply the results of experiments that had been done by other people. We can say that we use the “**data from the literature**”.

|  |  |
| --- | --- |
| **Cations** | **Anions** |
| OH− | Cl− | S2− |  |  |  |  |
| Na+ | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble |
| K+ | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble |
| Mg2+ | Insoluble | Soluble | Soluble | Soluble | Insoluble | Insoluble | Soluble |
| Ca2+ | Partly soluble | Soluble | Partly soluble | Partly soluble | Insoluble | Insoluble | Soluble |
| Ba2+ | Soluble | Soluble | Soluble | Insoluble | Insoluble | Insoluble | Soluble |
| Al3+ | Insoluble | Soluble | − | Soluble | Insoluble | − | Soluble |
| Zn2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Ag+ | − | Insoluble | Insoluble | Partly | Insoluble | Insoluble | Soluble |
| Cu2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Pb2+ | Insoluble | Partly soluble | Insoluble | Insoluble | Insoluble | Insoluble | Soluble |
| Fe2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Fe3+ | Insoluble | Soluble | − | Soluble | Insoluble | Insoluble | Soluble |

1. The word „**Soluble**” in the table means that the compound formed by the cation and anion is **soluble in water**, the “**Insoluble**” means that it is a **precipitate**.

2. We have to look for **anions** that form a precipitate both with the **Ca2+** and with the **Mg2+**.These are theand the **.**

3. The and the could only be used as water softeners in the form of **water soluble** compounds.These are the **Na2CO**3, the **Na3PO4**, the **K2CO3** and the **K3PO4**.

4. Among the 4 compounds above the washing soda (**Na2CO**3) and the trisodium phosphate (**Na3PO4**) are cheap.

5. According to the principle “**how to vary one thing at a time**”, we tried both potential softener with both ions that cause the hardness of water. We poured the **same volume** of the washing soda and sodium triphosphate to the solutions of Ca2+ and Mg2+ that had the **same volume and concentration** and we **filtered them in the same way**. Then the **same volume of soap solution** was added to **the same volume** of each filtrate and we shook them the **same number of times**, with the **same intensity** and then **measured the height of the foam in the same way** than in the Experiment 1.

Which of the washing soda and the trisodium phosphate causes more harmful environmental pollution and why?

…………………………………………………………………………………………………………………………………………………………………………….

The **phosphate free washing powders** contain active ingredients that are not sensitive to the hardness of water. There are also substances in them that reduce the hardness of water (e.g. zeolite that exchange the ions causing hardness to other ions).

**10. Student sheet: The “ancient enemy”**

(type 3: experiment-designing version for Group 3 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), except the Experiment 2 that goes as follows.*

**Water softeners** can be used for softening the water by **chemical** methods. These remove the ions causing the hardness by forming a **precipitate** with them (**that are hardly soluble in water**). In the Experiment 2 you will examine which compounds could be suitable as **water softeners**. The hard water will be **modelled** by CaCl2 solution and MgCl2 solution. You have to choose the substances **modelling the softeners** according to the following way of thinking.

**Experiment 2**:

a) Let us see, how we could work out in a **logical way of thinking**, knowing the **necessary facts and data**, which compounds are worth trying when we are looking for substances that are suitable for water softeners. The following **table** shows the **solubility of salts in water**. By using this table we apply the results of experiments that had been done by other people. We can say that we use the “**data from the literature**”.

1. The word „**Soluble**” in the table means that the compound formed by the cation and anion is **soluble in water**, the “**Insoluble**” means that it is a **precipitate**.

2. We have to look for **anions** that form a precipitate both with the **Ca2+** and with the **Mg2+**. Which are these?

…………………………………………………………………………………………………………………………………………………………………………….

|  |  |
| --- | --- |
| **Cations** | **Anions** |
| OH− | Cl− | S2− |  |  |  |  |
| Na+ | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble |
| K+ | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble |
| Mg2+ | Insoluble | Soluble | Soluble | Soluble | Insoluble | Insoluble | Soluble |
| Ca2+ | Partly soluble | Soluble | Partly soluble | Partly soluble | Insoluble | Insoluble | Soluble |
| Ba2+ | Soluble | Soluble | Soluble | Insoluble | Insoluble | Insoluble | Soluble |
| Al3+ | Insoluble | Soluble | − | Soluble | Insoluble | − | Soluble |
| Zn2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Ag+ | − | Insoluble | Insoluble | Partly | Insoluble | Insoluble | Soluble |
| Cu2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Pb2+ | Insoluble | Partly soluble | Insoluble | Insoluble | Insoluble | Insoluble | Soluble |
| Fe2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Fe3+ | Insoluble | Soluble | − | Soluble | Insoluble | Insoluble | Soluble |

3. The chosen anions could only be used as **water softeners** in the form of **water soluble** compounds.Which cations form **water soluble** salts with the chosen anions?

…………………………………………………………………………………………………………………………………………………………………………….

4. Which 4 compound seem to be suitable for softening the water?

…………………………………………………………………………………………………………………………………………………………………………….

5. Among the 4 compounds above the washing soda and the trisodium phosphate containing sodium ions are **cheap**. The “**tri**” in the name of trisodium phosphate means that there are **3** cations in its formula. Write down

the formula of washing soda: ………………… and its regular name: …………………………………………………………………………

and the formula of trisodium phosphate: ………………………………………

6. According to the principle “**how to vary one thing at a time**”, we have to try both potential softener with both ions that cause the hardness of water. This means four combinations. There are solutions containing the same amount of Ca2+ or Mg2+ ions in the test tubes 3. In the test tube 4 there is washing soda solution or trisodium phosphate solution that are concentrated enough to form a precipitate with all the calcium ions or magnesium ions. Do the experiments, fill in the following table and underline the **formulae of the** formed **precipitates** **in the reaction equations**.

|  |  |  |  |
| --- | --- | --- | --- |
| Teams | The mixed solutions | **Observations:** | **Explanations: (with reaction equations):** |
| Teams A)  | CaCl2 solution + ……………………… solution (washing soda) |  | CaCl2 + …………………….. =  |
| Teams B) | CaCl2 solution + ……………………… solution (trisodium phosphate) |  | CaCl2 + …………………….. = |
| Teams C) | MgCl2 solution + …………………….. solution (washing soda) |  | MgCl2 + …………………….. = |
| Teams D) | MgCl2 solution + …………………..… solution (trisodium phosphate) |  | MgCl2 + …………………….. =  |

b) Using a funnel and filter paper filter the content of the **test tube 3 into the test tube 4**. How could you examine whether you have managed to remove the ions causing the hardness of the water from the filtrate? Think of the Experiment 1! **Each team has to do the test exactly in the same way.**

**Plan of the experiment:** ……………………………………………………………………………………………………………………………………….

…………………………………………………………………………………………………………………………………………………………………………….

|  |  |  |  |
| --- | --- | --- | --- |
| Teams | The filtrate of the mixed solutions + soap solution | **Observations:** Height of the foam (cm) | **Conclusions/Explanations:** |
| Teams A)  | CaCl2 solution + ……………..… solution + …………………………. |  | The washing soda) (………………………) **is/ is not suitable** as a water softener. |
| Teams B) | CaCl2 solution + ……………..… solution + …………………………. |  | The trisodium phosphate) (…………………………) **is/ is not suitable** as a water softener. |
| Teams C) | MgCl2 solution + …………..… solution + …………………………. |  | The washing soda) (………………………) **is/ is not suitable** as a water softener. |
| Teams D) | MgCl2 solution + …………..… solution + …………………………. |  | The trisodium phosphate) (…………………………) **is/ is not suitable** as a water softener. |

Which of the washing soda and the trisodium phosphate causes more harmful environmental pollution and why?

…………………………………………………………………………………………………………………………………………………………………………….

The **phosphate free washing powders** contain active ingredients that are not sensitive to the hardness of water. There are also substances in them that reduce the hardness of water (e.g. zeolite that exchange the ions causing hardness to other ions).

**10. Student sheet: The “ancient enemy”**

(teacher notes)

We can often see housewives and plumbers fighting against the effect of **limescale** in the advertisements. The limescale deposited from **hard water** is not only **ugly**, but it is also **damaging** and **dangerous**. It increases the energy necessary to boil the water, due to its **heat insulation** effect, and it can even cause furnace explosion. The **soap does not form enough foam in the hard water**, its cleaning effect is reduced and even grey scum is formed. Therefore, **water softening** is important for the households and for the industry. This fact is exploited by the **cheaters** who want to sell the **pseudoscientific** “electric limescale preventer” and who call the limescale an “ancient enemy”. However, themselves are the “ancient enemy” who live of the ignorant people money…

Now we will investigate how the **water softening can be done in a really effective way**. First we have to find out **which cations cause the hardness of the water**. The following 4 cations are the most abundant in the natural waters, usually in the following order of their decreasing concentration: Ca2+> Mg2+> Na+> K+. In Experiment 1 you will investigate the effects of the four cations. (Anions do not cause water hardness.)

**Experiment 1**: There is 5 cm3 distilled water in the test tube 1 that you find on your tray. There is a solution of the compound (chloride) of the cation in the test tube 2 that your team will examine. Add 1 cm3 soap solution into both test tubes. Use the stoppers to close both test tubes and shake them ten times with the same intensity. Measure the height of the foam by the ruler in both test tubes and write the data in the table below. Then write the data of the other teams into the table and draw a conclusion.

While completing the worksheet, **underline or frame the correct or cross the not correct parts of the text.**

|  |  |  |
| --- | --- | --- |
| Teams | **Observations:** Height of the foam (cm) | **Conclusions/Explanations:** |
| in distilled water | in the salt solutions |
| Teams A)  | ***6-8 cm*** | CaCl2 solution: ***0 - 1 cm*** | Ca2+ **causes/does not cause** hardness. |
| Teams B) | ***6-8 cm*** | MgCl2 solution: ***0 - 1 cm*** | Mg2+ **causes/does not cause** hardness. |
| Teams C) | ***6-8 cm*** | NaCl solution: ***6-8 cm*** | Na+ **causes/does not cause** hardness. |
| Teams D) | ***6-8 cm*** | KCl solution: ***6-8 cm*** | K+ **causes/ does not cause** hardness. |

At the time of the **softening procedure**, the ***Ca2+-and Mg2****+* ions causing the hardness should be removed from the water. This could be done by **physical** and **chemical** methods. The **distilled water** is purified by a **physical** method. This could be bought, but it is too **expensive** to use it for instance for washing. Which **different physical property** of the water and its solutes (salts) is exploited at the time of **distillation**?

***Different boiling point (volatility).*** Why do you think the distilled water is expensive?

***Water distillation needs a lot of energy and it has a high price.***

[Only for type 1 and 2 student sheets.]

**Water softeners** can be used for softening the water by **chemical** methods. These remove the ions causing the hardness by forming a **precipitate** with them (**that are hardly soluble in water**). In the Experiment 2 you will examine whether the **washing soda** (Na2CO3) and the **trisodium phosphate** (Na3PO4) that are suggested water softeners have really got that **softening** effect. The hard water will be **modelled** by CaCl2 solution and MgCl2 solution, whereas the softeners with sodium carbonate (Na2CO3) and trisodium phosphate (Na3PO4). The four different types of teams will try the 4 different possible combinations.

**Experiment 2**:

a) There are 5 cm3 solution in both the test tube 3 and test tube 4 on your tray. In the test tube 3 there is CaCl2 solution for teams A) and teams B), and MgCl2 solution for teams C) and teams D). In the test tube 4 there is washing soda solution for teams A) and teams C), and trisodium phosphate solution for teams B) and teams D) that are concentrated enough to form a precipitate with all the calcium ions or magnesium ions. Pour all the liquid **from the test tube 4 to the test tube 3.**

Write down the **observations** of all the four types of teams into the following table, finish and balance the **equations** together. Underline the **formulae of the precipitates** formed **in the reaction equations**.

|  |  |  |  |
| --- | --- | --- | --- |
| Teams | The mixed solutions | **Observations:** | **Explanations: (with reaction equations):** |
| Teams A)  | CaCl2 solution + Na2CO3 solution (washing soda) | ***white precipitate formed*** | CaCl2 + Na2CO3 = ***CaCO3 +2 NaCl*** |
| Teams B) | CaCl2 solution + Na3PO4- solution (trisodium phosphate) | ***white precipitate formed*** | ***3*** CaCl2 + ***2*** Na3PO4 = ***Ca3(PO4)2 +6 NaCl*** |
| Teams C) | MgCl2 solution + Na2CO3 solution (washing soda) | ***white precipitate formed*** | MgCl2 + Na2CO3 = ***MgCO3 +2 NaCl*** |
| Teams D) | MgCl2 solution + Na3PO4 solution (trisodium phosphate) | ***white precipitate formed*** | **3** MgCl2 + ***2*** Na3PO4 = ***Mg3(PO4)2 +6 NaCl*** |

b) Using a funnel and filter paper filter the content of the **test tube 3 into the test tube 4** (in that the washing soda or the trisodium phosphate had been). Measure 5 cm3 of the filtrate into the test tube 5 and add 1 cm3 soap solution. Use the stoppers to close the test tube and shake it ten times. Measure the height of the foam by the ruler and write the data in the table below. Compare these with the observations of the Experiment 1 and draw a conclusion.

|  |  |  |  |
| --- | --- | --- | --- |
| Teams | The filtrate of the mixed solutions + soap solution | **Observations:** Height of the foam (cm) | **Conclusions/Explanations:** |
| Teams A)  | CaCl2 solution + Na2CO3 solution + soap solution | ***4-5 cm*** | Na2CO3 solution (washing soda) + **is suitable/is not suitable** as a water softener. |
| Teams B) | CaCl2 solution + Na3PO4- solution + soap solution | ***6-8 cm*** | Na3PO4 solution (trisodium phosphate) **is suitable/is not suitable** as a water softener. |
| Teams C) | MgCl2 solution + Na2CO3 solution + soap solution | **2-3 cm** | Na2CO3 solution (washing soda) + **is suitable/is not suitable** as a water softener. |
| Teams D) | MgCl2 solution + Na3PO4 solution + soap solution | ***6-8 cm*** | Na3PO4 solution (trisodium phosphate) **is suitable/is not suitable** as a water softener. |

[Only for type 2 student sheets.]

Now, let us have a look, how we could have worked out knowing the **table below** that shows the **solubility of salts in water, which compounds are suitable water softeners** and how this experiment could have been **designed**. By using this table we apply the results of experiments that had been done by other people. We can say that we use the “**data from the literature**”.

|  |  |
| --- | --- |
| **Cations** | **Anions** |
| OH− | Cl− | S2− |  |  |  |  |
| Na+ | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble |
| K+ | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble |
| Mg2+ | Insoluble | Soluble | Soluble | Soluble | Insoluble | Insoluble | Soluble |
| Ca2+ | Partly soluble | Soluble | Partly soluble | Partly soluble | Insoluble | Insoluble | Soluble |
| Ba2+ | Soluble | Soluble | Soluble | Insoluble | Insoluble | Insoluble | Soluble |
| Al3+ | Insoluble | Soluble | − | Soluble | Insoluble | − | Soluble |
| Zn2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Ag+ | − | Insoluble | Insoluble | Partly | Insoluble | Insoluble | Soluble |
| Cu2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Pb2+ | Insoluble | Partly soluble | Insoluble | Insoluble | Insoluble | Insoluble | Soluble |
| Fe2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Fe3+ | Insoluble | Soluble | − | Soluble | Insoluble | Insoluble | Soluble |

1. The word „**Soluble**” in the table means that the compound formed by the cation and anion is **soluble in water**, the “**Insoluble**” means that it is a **precipitate**.

2. We have to look for **anions** that form a precipitate both with the **Ca2+** and with the **Mg2+**.These are theand the **.**

3. The and the could only be used as water softeners in the form of **water soluble** compounds.These are the **Na2CO**3, the **Na3PO4**, the **K2CO3** and the **K3PO4**.

4. Among the 4 compounds above the washing soda (**Na2CO**3) and the trisodium phosphate (**Na3PO4**) are cheap.

5. According to the principle “**how to vary one thing at a time**”, we tried both potential softener with both ions that cause the hardness of water. We poured the **same volume** of the washing soda and sodium triphosphate to the solutions of Ca2+ and Mg2+ that had the **same volume and concentration** and we **filtered them in the same way**. Then the **same volume of soap solution** was added to **the same volume** of each filtrate and we shook them the **same number of times**, with the **same intensity** and then **measured the height of the foam in the same way** than in the Experiment 1.

[Only for type 3 student sheets.]

**Water softeners** can be used for softening the water by **chemical** methods. These remove the ions causing the hardness by forming a **precipitate** with them (**that are hardly soluble in water**). In the Experiment 2 you will examine which compounds could be suitable as **water softeners**. The hard water will be **modelled** by CaCl2 solution and MgCl2 solution. You have to choose the substances **modelling the softeners** according to the following way of thinking.

**Experiment 2**:

a) Let us see, how we could work out in a **logical way of thinking**, knowing the **necessary facts and data**, which compounds are worth trying when we are looking for substances that are suitable for water softeners. The following **table** shows the **solubility of salts in water**. By using this table we apply the results of experiments that had been done by other people. We can say that we use the “**data from the literature**”.

1. The word „**Soluble**” in the table means that the compound formed by the cation and anion is **soluble in water**, the “**Insoluble**” means that it is a **precipitate**.

2. We have to look for **anions** that form a precipitate both with the **Ca2+** and with the **Mg2+**. Which are these?

 ***and .***

|  |  |
| --- | --- |
| **Cations** | **Anions** |
| OH− | Cl− | S2− |  |  |  |  |
| Na+ | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble |
| K+ | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble | Soluble |
| Mg2+ | Insoluble | Soluble | Soluble | Soluble | Insoluble | Insoluble | Soluble |
| Ca2+ | Partly soluble | Soluble | Partly soluble | Partly soluble | Insoluble | Insoluble | Soluble |
| Ba2+ | Soluble | Soluble | Soluble | Insoluble | Insoluble | Insoluble | Soluble |
| Al3+ | Insoluble | Soluble | − | Soluble | Insoluble | − | Soluble |
| Zn2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Ag+ | − | Insoluble | Insoluble | Partly | Insoluble | Insoluble | Soluble |
| Cu2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Pb2+ | Insoluble | Partly soluble | Insoluble | Insoluble | Insoluble | Insoluble | Soluble |
| Fe2+ | Insoluble | Soluble | Insoluble | Soluble | Insoluble | Insoluble | Soluble |
| Fe3+ | Insoluble | Soluble | − | Soluble | Insoluble | Insoluble | Soluble |

3. The chosen anions could only be used as **water softeners** in the form of **water soluble** compounds.Which cations form **water soluble** salts with the chosen anions?

***The sodium ion and the potassium ion.***

4. Which 4 compound seem to be suitable for softening the water?

***Na2CO3, Na3PO4, K2CO3 and K3PO4.***

5. Among the 4 compounds above the washing soda and the trisodium phosphate containing sodium ions are **cheap**. The “**tri**” in the name of trisodium phosphate means that there are **3** cations in its formula. Write down

the formula of washing soda: and its regular name: ***Na2CO3 and sodium carbonate***

and the formula of trisodium phosphate: ***Na3PO4***

6. According to the principle “**how to vary one thing at a time**”, we have to try both potential softener with both ions that cause the hardness of water. This means four combinations. There are solutions containing the same amount of Ca2+ or Mg2+ ions in the test tubes 3. In the test tube 4 there is washing soda solution or trisodium phosphate solution that are concentrated enough to form a precipitate with all the calcium ions or magnesium ions. Do the experiments, fill in the following table and underline the **formulae of the** formed **precipitates** **in the reaction equations**.

|  |  |  |  |
| --- | --- | --- | --- |
| Teams | The mixed solutions | **Observations:** | **Explanations: (with reaction equations):** |
| Teams A)  | CaCl2 solution + ***Na2CO3*** solution (washing soda) | ***white precipitate formed*** | CaCl2 + ***Na2CO3***= ***CaCO3 +2 NaCl*** |
| Teams B) | CaCl2 solution + ***Na3PO4*** solution (trisodium phosphate) | ***white precipitate formed*** | ***3*** CaCl2 + ***2 Na3PO4*** =***Ca3(PO4)2 +6 NaCl*** |
| Teams C) | MgCl2 solution + ***Na2CO3*** solution (washing soda) | ***white precipitate formed*** | MgCl2 + ***Na2CO3*** = ***MgCO3 +2 NaCl*** |
| Teams D) | MgCl2 solution + ***Na3PO4*** solution (trisodium phosphate) | ***white precipitate formed*** | ***3*** MgCl2 + ***2 Na3PO4*** = ***Mg3(PO4)2 +6 NaCl*** |

b) Using a funnel and filter paper filter the content of the **test tube 3 into the test tube 4**. How could you examine whether you have managed to remove the ions causing the hardness of the water from the filtrate? Think of the Experiment 1! **Each team has to do the test exactly in the same way.**

**Plan of the experiment: *5 cm3 should be measured out from each filtrate and 1 cm3 soap solution should be added to them. Then they have to be shaken ten times and the height of the foam should be measured by a ruler.***

|  |  |  |  |
| --- | --- | --- | --- |
| Teams | The filtrate of the mixed solutions + soap solution | **Observations:** Height of the foam (cm) | **Conclusions/Explanations:** |
| Teams A)  | CaCl2 solution + ***Na2CO3***solution + ***soap solution*** | ***4-5 cm*** | Na2CO3 solution (washing soda) + **is suitable/is not suitable** as a water softener. |
| Teams B) | CaCl2 solution + ***Na3PO4***solution + ***soap solution*** | ***6-8 cm*** | Na3PO4 solution (trisodium phosphate) **is suitable/is not suitable** as a water softener. |
| Teams C) | MgCl2 solution + ***Na2CO3***solution + ***soap solution*** | **2-3 cm** | Na2CO3 solution (washing soda) + **is suitable/is not suitable** as a water softener. |
| Teams D) | MgCl2 solution + ***Na3PO4*** solution + ***soap solution*** | ***6-8 cm*** | Na3PO4 solution (trisodium phosphate) **is suitable/is not suitable** as a water softener. |

[For all the three types of groups.]

Which of the washing soda and the trisodium phosphate causes more harmful environmental pollution and why?

***The trisodium phosphate, because it causes eutrophication.***

The **phosphate free washing powders** contain active ingredients that are not sensitive to the hardness of water. There are also substances in them that reduce the hardness of water (e.g. zeolite that exchange the ions causing hardness to other ions).

END OF THE 10. STUDENT SHEETS AND TEACHER NOTES

**11. Student sheet: Lime in the limelight**

(type 1: ‘step-by-step’ version for Group 1 students)

Calcium carbonate is a fantastic substance! You can find it in limestone, in marble, in limescale, in eggshell, in the shell of snails, in scouring powder, in toothpaste, in soil additives, in antacids, and in food additives (E170) too. Its reactions play an important role in the processes taking place in the **industry**, in the **households** and in the **environment**. At the time of **calcination**, as a result of **heating**,the **calcium carbonate** content **of the limestone** decomposes to **calcium oxide** and **carbon dioxide**. At the time of the **lime slaking**, **quicklime**, i.e. **calcium oxide** reacts with **water** and forms **calcium hydroxide**, which is commonly called **slaked lime**. This is used for **construction** works. The slaked lime is a **highly corrosive, caustic alkali**. **Lime slaking is dangerous**, because the hot, highly alkaline solution can splash, as a result of the **produced heat**. The phrase “in the limelight” refers to the equipment used in theatres. A mixture of hydrogen and oxygen was burnt in it and the produced heat was used to heat quicklime, so that it was glowing in a bright white. In Experiment 1, the processes of calcination and the lime slaking are modelled.

**Experiment 1**: Light the burner. Hold the little piece of limestone into the flame by a pair of tweezers for about 2 minutes. Then wait for about half a minute. Put the calcinated limestone into one of the cups containing phenolphthalein and water. Fill in the observations below and the explanations too, thinking of what you read above.

**Observation:** The colour of the solution has changed from …………………………………………… to ……………………………….

**Explanation:** While heating the limestone (“**calcination**”) a reaction took place that can be described by the

following equation: ………………………………………………………………………………………………………………………………………………

When the burnt lime was put into water (“**lime slaking**”) a reaction took place that can be described by the

following equation: ………………………………………………………………………………………………………………………………………………

The colour of the phenolphthalein indicated that the solution became ………………………………………………… that was

caused by the …………………………………………………………………………………………………….

Sometimes, on the ground of the terminology used in everyday life, it is not easy to work out what contains calcium oxide, what calcium hydroxide and what calcium carbonate. However, the solidity of the **eggshell** is also ensured by the calcium carbonate. This can be proved by the Experiment 2.

**Experiment 2**: Light the burner again. Hold the little piece of eggshell into the flame by a pair of tweezers for about 1 minute. Observe the changes, and after a little while put it into the other cup containing phenolphthalein and water. Fill in the observations and the explanations below.

**Observations:** The eggshell held in the flame first became …………………………………………… colour, then it changed

to ………………………………. on the edges. The colourless solution became ……………………………………………….. colour, as an effect of the burnt eggshell.

**Explanations:** The decomposition of the carbon containing compounds in the eggshell caused the ………………………

colour. The ………………………………… colour substance that has got a chemical name ……………………………………………….

was formed from the ……………………………………………………………….. that is in the eggshell. If the latter is put into

water ………………………………………………………………………….. forms. Its solution is …………………………………………… that is

indicated by the phenolphthalein. The main constituent of the eggshell is ……………………………………………………………

**Carbonates** react with **acids**. That is why the calcium carbonate can be used to remove the unnecessary acid from the stomach, from a wine, from soft drinks and from the soil. However, that is why the acid rain ruins the houses and statues made of limestone. Limescale removers also utilise that reaction that is modelled by the Experiment 3.

**Experiment 3**: Put some broken limestone into the test tube containing hydrochloric acid. Hold a burning splint into the test tube.

**Observations:** There was ………………………………………… in the test tube. The burning splint ……………………………………

**Explanations:** The fizzing shows the development of a ………………………………. It can be concluded from the

behaviour of the burning splint that it is the …………………………………………………………….. gas. The equation of the reaction taking place between the calcium carbonate and the hydrochloric acid is a follows:

…………………………………………………………………………………………………………………………………………………………………………….

Because of the reaction taking place between the carbonates and acids the **limestone inhibits the acidification of the natural waters**. In the Experiment 4 it will be **modelled**, whether the **acidification of the lake water caused by the acid rain** is influenced by the rocks of the waterbed (if it is made of **sand** or **limestone**).

**Experiment 4**: There is distilled water and red cabbage juice in all the three beakers. Make a note of the **colour** in the **1st line** of the table below. Add 2 drops of vinegar to the content of each beaker and stir the solutions. Make a note of the colour of the solutions in the **2nd line** of the table below. Add a spoonful of sand to the content of the beaker 2 and a spoonful of broken limestone to the content of the beaker 3. Stir the solutions for about 3 minutes and make notes of the **colour of the solutions** in the **3rd line** of the table below.

**Observations:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Beaker 1 | Beaker 2 | Beaker 3 |
| 1. | distilled water + red cabbage juice: | distilled water + red cabbage juice: | distilled water + red cabbage juice: |
| 2. | + vinegar: | + vinegar: | + vinegar: |
| 3. | after 3 minutes: | + sand, after 3 minutes: | + limestone, after 3 minutes: |

While completing the worksheet, **underline or frame the correct or cross the not correct parts of the text.**

**Explanations:** Thered cabbage juice has ………………………………………. colour in the distilled water, because it is

…………………………………………………………… After adding the vinegar, the red cabbage juice indicator showed that it

is ………………………………………………… After adding the sand, the ………………………………………… of the solution **changes/does not change,** because the sand **reacts/does not react** with the acid. After adding the limestone,

the ………………………………………… of the solution **changes/does not change,** because the limestone **reacts/does**

**not react** with the acid. Therefore the …………………………………………………. can **counterbalance the effect of the**

**acid rain** and inhibits the acidification of the lakewater. The ………………………………………………. cannot do that, because it does not react with acids. Experiment 1, Experiment 3 and Experiment 4 were so called “**model experiments**”, because they showed the **chemical essence** of chemical processes taking place in the reality.

**11. Student sheet: Lime in the limelight**

(type 2: ‘step-by-step’ version + explanation of experiment-design for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but after the last but one sentence of the Experiment 4 the worksheet also contains the text below that the students have to read, fill in and discuss with their teacher.*

Experiment 4 was a so called “**model experiment**”, because it showed the **chemical essence** of a chemical process taking place in the reality. To do that, first the **materials** had to be chosen that **replace** their following equivalents in the **reality**:

The vinegar replaces the …………………………………………………………………………………………………..

The distilled water replaces the ………………………………………………………………………………….……..

The sand replaces the ……………………………………………………………………………………………………..…

The limestone replaces the …………………………………………………………………………………………….….

Then by using suitable **equipment**, we made a **chemical reaction** happen, that also takes place in nature. Write down, what is the chemical reaction that takes place in nature which is the equivalent of the reaction between limestone and vinegar:

…………………………………………………………………………………………………………………………………………………………………………….

We had to show that the reaction happened. That was **indicated** by the **colour** **change** of the

……………………………………………………………………

The effect of limestone was **compared** to the effect of sand. Therefore, the sand was a **reference material**. The beaker 1 containing **distilled water** showed, how the acidity changes as an effect of the acid, if neither of the two materials to be compared (limestone and sand) are present. This was the so called **control experiment**.

Which were the **model experiments** among the Experiment 1, Experiment 2 and Experiment 3?

…………………………………………………………………………………………………………………………………………………………………………….

**11. Student sheet: Lime in the limelight**

(type 3: experiment-designing version for Group 3 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), except the Experiment 4 that goes as follows.*

**Experiment 4**: To design the experiment, first the **materials** had to be chosen that **replace** their following equivalents:

The water of the lake: …………………………………………………………………………………………………..

The acid rain: ………………………………………………………………………………….……..

The sandy waterbed: ……………………………………………………………………………………………………..…

The waterbed made of limestone: …………………………………………………………………………………………….….

Then a **chemical reaction** has to happen, that also takes place in the **reality**. How could you “**mimic**”, using the materials above, the chemical reaction taking place in nature between the acid rain and limestone?

 …………………………………………………………………………………………………………………………………………………………………………….

How could it be **indicated** that a reaction has taken place?…………………………………………………………………………..………

To the effect of which material should the effect of the limestone be **compared**? (“**Reference material**”):

………………………………………

A **control experiment** is also needed, when neither of the two materials to be compared is present. What is needed for this?

…………………………………………………………………………………………………………………………………………………………………………….

What **equipment** is necessary for the experiment?

...................................................................................................................................................................................

**Plan of the series of experiment:**

Step 1: ……………………………………………………………………………………………………………………………………………………………….

Step 2: ……………………………………………………………………………………………………………………………………………………………….

Step 3: ……………………………………………………………………………………………………………………………………………………………….

Step 4: ……………………………………………………………………………………………………………………………………………………………….

**Observations**: Summarize these in this table!

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |
|  |  |  |
|  |  |  |

**Explanations:** …………………………………………………………………………………………………………………………………………………….

…………………………………………………………………………………………………………………………………………………………………………….

While completing the worksheet, **underline or frame the correct or cross the not correct parts of the text.**

**Explanations:** After adding the sand, the ………………………………………… of the solution **changes/does not change,** because the sand **reacts/does not react** with the acid. After adding the limestone, the

………………………………………… of the solution **changes/does not change,** because the limestone **reacts/does**

**not react** with the acid. Therefore the …………………………………………………. can **counterbalance the effect of the**

**acid rain** and inhibits the acidification of the lakewater. The ………………………………………………. cannot do that, because it does not react with acids.

Which were the **model experiments** among the Experiment 1, Experiment 2 and Experiment 3?

…………………………………………………………………………………………………………………………………………………………………………….

**11. Student sheet: Lime in the limelight[[5]](#footnote-5)**

(teacher notes)

Calcium carbonate is a fantastic substance! You can find it in limestone, in marble, in limescale, in eggshell, in the shell of snails, in scouring powder, in toothpaste, in soil additives, in antacids, and in food additives (E170) too. Its reactions play an important role in the processes taking place in the **industry**, in the **households** and in the **environment**. At the time of **calcination**, as a result of **heating**,the **calcium carbonate** content **of the limestone** decomposes to **calcium oxide** and **carbon dioxide**. At the time of the **lime slaking**, **quicklime**, i.e. **calcium oxide** reacts with **water** and forms **calcium hydroxide**, which is commonly called **slaked lime**. This is used for **construction** works. The slaked lime is a **highly corrosive, caustic alkali**. **Lime slaking is dangerous**, because the hot, highly alkaline solution can splash, as a result of the **produced heat**. The phrase “in the limelight” refers to the equipment used in theatres. A mixture of hydrogen and oxygen was burnt in it and the produced heat was used to heat quicklime, so that it was glowing in a bright white. In Experiment 1, the processes of calcination and the lime slaking are modelled.

**Experiment 1**: Light the burner. Hold the little piece of limestone into the flame by a pair of tweezers for about 2 minutes. Then wait for about half a minute. Put the calcinated limestone into one of the cups containing phenolphthalein and water. Fill in the observations below and the explanations too, thinking of what you read above.

**Observation:** The colour of the solution has changed from ***colourless*** to ***pink/purple***.

**Explanation:** While heating the limestone (“**calcination**”) a reaction took place that can be described by the

following equation: ***CaCO3 = CaO + CO2***

When the burnt lime was put into water (“**lime slaking**”) a reaction took place that can be described by the

following equation: ***CaO + H2O = Ca(OH)2***.

The colour of the phenolphthalein indicated that the solution became ***alkaline*** that was caused by the ***calcium hydroxide / hydroxide ion.***

Sometimes, on the ground of the terminology used in everyday life, it is not easy to work out what contains calcium oxide, what calcium hydroxide and what calcium carbonate. However, the solidity of the **eggshell** is also ensured by the calcium carbonate. This can be proved by the Experiment 2.

**Experiment 2**: Light the burner again. Hold the little piece of eggshell into the flame by a pair of tweezers for about 1 minute. Observe the changes, and after a little while put it into the other cup containing phenolphthalein and water. Fill in the observations and the explanations below.

**Observations:** The eggshell held in the flame first became ***black*** colour, then it changed to ***white*** on the edges. The colourless solution became ***pink/purple*** colour, as an effect of the burnt eggshell.

**Explanations:** The decomposition of the carbon containing compounds in the eggshell caused the ***black*** colour. The ***white*** colour substance that has got a chemical name ***calcium oxide*** was formed from the ***calcium carbonate*** that is in the eggshell. If the latter is put into water ***calcium hydroxide*** forms. Its solution is ***alkaline*** that is indicated by the phenolphthalein. The main constituent of the eggshell is ***calcium carbonate***.

**Carbonates** react with **acids**. That is why the calcium carbonate can be used to remove the unnecessary acid from the stomach, from a wine, from soft drinks and from the soil. However, that is why the acid rain ruins the houses and statues made of limestone. Limescale removers also utilise that reaction that is modelled by the Experiment 3.

**Experiment 3**: Put some broken limestone into the test tube containing hydrochloric acid. Hold a burning splint into the test tube.

**Observations:** There was ***a fizzing*** in the test tube. The burning splint ***went out***.

**Explanations:** The fizzing shows the development of a ***gas***. It can be concluded from the behaviour of the burning splint that it is the ***carbon dioxide*** gas. The equation of the reaction taking place between the calcium carbonate and the hydrochloric acid is a follows: ***CaCO3 + 2 HCl = CaCl2 + H2O + CO2↑***

Because of the reaction taking place between the carbonates and acids the **limestone inhibits the acidification of the natural waters**. In the Experiment 4 it will be **modelled**, whether the **acidification of the lake water caused by the acid rain** is influenced by the rocks of the waterbed (if it is made of **sand** or **limestone**).

[Only for type 1 and 2 student sheets.]

**Experiment 4**: There is distilled water and red cabbage juice in all the three beakers. Make a note of the **colour** in the **1st line** of the table below. Add 2 drops of vinegar to the content of each beaker and stir the solutions. Make a note of the colour of the solutions in the **2nd line** of the table below. Add a spoonful of sand to the content of the beaker 2 and a spoonful of broken limestone to the content of the beaker 3. Stir the solutions for about 3 minutes and make notes of the **colour of the solutions** in the **3rd line** of the table below.

**Observations:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Beaker 1 | Beaker 2 | Beaker 3 |
| 1. | distilled water + red cabbage juice: ***lilac/violet*** | distilled water + red cabbage juice: ***lilac/violet*** | distilled water + red cabbage juice: ***lilac/violet*** |
| 2. | + vinegar: ***red/pink*** | + vinegar: ***red/pink*** | + vinegar: ***red/pink*** |
| 3. | after 3 minutes: ***red/pink*** | + sand, after 3 minutes: ***red/pink*** | + limestone, after 3 minutes: between ***red/pink and lilac/violet*** |

While completing the worksheet, **underline or frame the correct or cross the not correct parts of the text.**

**Explanations:** Thered cabbage juice has ***lilac/violet*** colour in the distilled water, because it is ***neutral***. After adding the vinegar, the red cabbage juice indicator showed that it is ***acidic***. After adding the sand, the ***acidity*** of the solution **changes/does not change,** because the sand **reacts/ does not react** with the acid. After adding the limestone, the ***acidity*** of the solution **changes/does not change,** because the limestone **reacts/does not react** with the acid. Therefore the ***limestone*** can **counterbalance the effect of the acid rain** and inhibits the acidification of the lakewater. The ***sand*** cannot do that, because it does not react with acids.

[Only for type 1 student sheets.]

Experiment 1, Experiment 3 and Experiment 4 were so called “**model experiments**”, because they showed the **chemical essence** of chemical processes taking place in the reality.

[Only for type 2 student sheets.]

Experiment 4 was a so called “**model experiment**”, because it showed the **chemical essence** of a chemical process taking place in the reality. To do that, first the **materials** had to be chosen that **replace** their following equivalents in the **reality**:

The vinegar replaces the ***acid rain***.

The distilled water replaces the ***lakewater***.

The sand replaces the ***sandy waterbed***.

The limestone replaces the ***waterbed made of limestone***.

Then by using suitable **equipment**, we made a **chemical reaction** happen, that also takes place in nature. Write down, what is the chemical reaction that takes place in nature which is the equivalent of the reaction between limestone and vinegar:

***The reaction that takes place between the acid rain and the limestone.***

We had to show that the reaction happened. That was **indicated** by the **colour** **change** of the ***red cabbage juice.***

The effect of limestone was **compared** to the effect of sand. Therefore, the sand was a **reference material**. The beaker 1 containing **distilled water** showed, how the acidity changes as an effect of the acid, if neither of the two materials to be compared (limestone and sand) are present. This was the so called **control experiment**.

[Only for type 3 student sheets.]

**Experiment 4**: To design the experiment, first the **materials** had to be chosen that **replace** their following equivalents:

The water of the lake: ***distilled water***

The acid rain: ***vinegar***

The sandy waterbed: ***sand***

The waterbed made of limestone: ***limestone***

Then a **chemical reaction** has to happen, that also takes place in the **reality**. How could you “**mimic**”, using the materials above, the chemical reaction taking place in nature between the acid rain and limestone?

***The limestone has to be put into water that contains vinegar.***

How could it be **indicated** that a reaction has taken place? ***By the (colour change of the) red cabbage juice.***

To the effect of which material should the effect of the limestone be **compared**? (“**Reference material**”): ***To that of the sand.***

A **control experiment** is also needed, when neither of the two materials to be compared is present. What is needed for this? ***Distilled water, red cabbage juice and vinegar.***

What **equipment** is necessary for the experiment? ***3 beakers, 3 stirring rods, 2 droppers, 2 spoons***

**Plan of the series of experiment:**

Step 1: ***The same amount of distilled water has to be put in each beaker.***

Step 2: ***The same number of drops of red cabbage juice has to be added to the content of each beaker.***

Step 3: ***The same number of drops of vinegar has to be added to the content of each beaker.***

Step 4: ***A spoonful of sand has to be added to the content of one beaker and a spoonful of limestone has to be added to the content of the other beaker and they have to be stirred for the same length of time (e.g. 3 minutes). (The content of the third beaker is the control experiment.***

**Observations**:Summarize these in this table!

|  |  |  |  |
| --- | --- | --- | --- |
|  | Beaker 1 | Beaker 2 | Beaker 3 |
| 1. | distilled water + red cabbage juice: ***lilac/violet*** | distilled water + red cabbage juice: ***lilac/violet*** | distilled water + red cabbage juice: ***lilac/violet*** |
| 2. | + vinegar: ***red/pink*** | + vinegar: ***red/pink*** | + vinegar: ***red/pink*** |
| 3. | after 3 minutes: ***red/pink*** | + sand, after 3 minutes: ***red/pink*** | + limestone, after 3 minutes: between ***red/pink and lilac/violet*** |

**Explanations:** ***The red cabbage juice has got lilac/violet colour in the neutral distilled water. After adding the vinegar, the red cabbage juice indicates that the solution is acidic. The limestone neutralizes the acidity of the solution.***

While completing the worksheet, **underline or frame the correct or cross the not correct parts of the text.**

**Explanations:** After adding the sand, the ***acidity*** of the solution **changes/does not change,** because the sand **reacts/ does not react** with the acid. After adding the limestone, the ***acidity*** of the solution **changes/does not change,** because the limestone **reacts/does not react** with the acid. Therefore the ***limestone*** can **counterbalance the effect of the acid rain** and inhibits the acidification of the lakewater. The ***sand*** cannot do that, because it does not react with acids.

[Only for type 2 and type 3 student sheets.]

Which were the **model experiments** among the Experiment 1, Experiment 2 and Experiment 3?

***Experiment 1 and Experiment 3.***

END OF THE 11. STUDENT SHEETS AND TEACHER NOTES

**12. Student sheet: Milk, the complete food**

(type 1: ‘step-by-step’ version for Group 1 students)

Milk has been regarded essential for life, strength and health since the ancient times. The new-born mammals’ (including humans’) first food is milk. Brest milk (mother’s milk) contains especially many different nutrients. Its constitution can change according to the baby’s needs and age. At this lesson you will investigate, whether milk is a complete food. To justify this statement, you have to prove that each type of nutrients can be found in it. While doing your homework, you had a look at the vitamins and minerals that are in the milk. Next we will test for the other nutrients. Each nutrient will be tested by different teams.

Type I. teams will do the Experiment 1, which is the test of fat in milk. Type II. teams will do the Experiment 2, which is the test of sugar in milk. Type III. teams will do the Experiment 3, which is the test of proteins in milk.

After finishing the experiments write down your experiences and the explanations, **underline or frame the correct or cross the not correct parts of the text.** When you are ready, discuss the experiences of each experiment with the other teams and write down the explanations.

**Experiment 1.a**: Pour water in a test tube to about 4 cm height and add cooking oil to it to about 2 cm height. Use the stopper and shake the content of the test tube vigorously. What do you see?

**Observation:** The water and the oil are **miscible/immiscible**.

**Explanation:** The oil **dissolves in water/fat**, therefore it **separates/does not separate** from water.

Then add petrol to the content of the test tube to about 2 cm height, use the stopper and shake it again. What do you see now?

**Observation:** The water and the petrol are **miscible/immiscible**.

**Explanation:** The oil **dissolves in water/fat**.

Then place 1 drop of oil and 1 drop of petrol (separately, but at the same time) on a piece of filter paper and observe what happens. (Make a sign on the filter paper what substance was dropped where.)

**Observation:** The …………………………………………. evaporated very quickly after dropping the oil and the petrol on

the filter paper, but the …………………………………………….. left a patch on the paper.

**Explanation:** That substance evaporates more quickly of the oil and petrol, in which the interactions among the particles are **stronger/weaker**.

At last place 1 drop of the liquid to on the filter paper from the upper layer of the liquid in the test tube. What has happened now?

**Observation:** The sample taken from the upper layer of the content of the test tube left a patch on the paper that is similar to the **oil/petrol**.

**Explanation:** The sample taken from the upper layer of the content of the test tube contained …………………………….

and ……………………….… The …………………………… evaporated, while the …………………………… remained on the paper.

**Experiment 1.b**: Pour milk in a test tube to about 4 cm height and add petrol to it to about 2 cm height. Use the stopper and shake the content of the test tube vigorously. What do you see?

**Observation:** ……………………………………………………………………………………………………………………………………………………….

**Explanation**: ………………………………………………………………………………………………………………………………………………………

…………………………………………………………………………………………………………………………………………………………………………….

**Experiment 1.c**: PLace 1 drop of the upper layer of the liquid being in the test tube containing milk and petrol on a filter paper. Watch what happens for a few minutes!

**Observation:** ……………………………………………………………………………………………………………………………………………………….

**Explanation**: ………………………………………………………………………………………………………………………………………………………

…………………………………………………………………………………………………………………………………………………………………………….

**Experiment 2.a**: Add Fehling’s reagent II drop-by-drop to the Fehling’s reagent I you find in a test tube, until the precipitate that forms in the beginning dissolves with a deep blue colour. Shake the content of the test tube to help the dissolution of the precipitate. Pour one third of the prepared “Fehling reagent” to the glucose solution and heat it in the flame of the burner. What do you see?

**Observation:** A …………………………………….. colour precipitate formed in the test tube containing **glucose**.

**Explanation:** The “Fehling test” that you have just done can be used to show the presence of certain sugars that belong to the carbohydrates (e.g. glucose, lactose and maltose). If the tested liquid contains this type of sugar,

then a …………………………………………….. colour precipitate forms.

**Experiment 2.b**: Pour the second third of the prepared “Fehling reagent” to the milk in the test tube and heat it. What do you see? What can you conclude of this?

**Observation:** ……………………………………………………………………………………………………………………………………………………….

**Explanation**: ………………………………………………………………………………………………………………………………………………………

…………………………………………………………………………………………………………………………………………………………………………….

**Experiment 3.a**: Add one third of the sodium hydroxide solution that you find in the test tube to the egg white solution. Then add 5 drops of copper sulphate solution to it. Shake the content of the test tube and observe the colour change.

**Observation:** The content of the test tube containing egg white became …………………………………….. colour.

**Explanation:** The reaction that has taken place is called the “biuret test” that is used for detecting the presence of a certain part of molecules that is characteristic of proteins. The essence of it is that in an alkaline solution the

copper (II) ions form a …………………………………………. colour substance with proteins.

**Experiment 3.b**: Accomplish the biuret test described above with the milk in the test tube. Observe the colour change. What can you conclude from this?

**Observation:** ……………………………………………………………………………………………………………………………………………………….

**Explanation**: ………………………………………………………………………………………………………………………………………………………

…………………………………………………………………………………………………………………………………………………………………………….

Doing the three experiments we have managed to prove that the milk contains …………………………………………………,

……………………………………….. and ………………………………………………. too. While doing the homework, we stated that

vitamins and minerals can also be found in it. According to these, milk is a ………………………………………..food.

**12. Student sheet: Milk, the complete food**

(type 2: ‘step-by-step’ version + explanation of experiment-design for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but after the Experiment 3.b the worksheet also contains the text below that the students have to read and discuss with their teacher.*

While doing the experiments you used **tests**. The purpose of these tests in chemistry to **show whether a substance (or group of substances) that has got a certain property is present** in the sample.

At this lesson you proved the presence of different nutrients (fat, carbohydrate, protein) in the milk. A test is good, if the expected change only happens when a substance (or group of substances) that has got a certain property is present, and does not happen in any other cases. Therefore you first did the tests with substances when the test is “**positive**” (i.e. you proved the presence of the given substance). Then you **compared** the result with the reagent itself, in that the substance (fat, carbohydrate or protein) was not present. Then you applied the tests in the case of the milk too, proving the presence of the given constituent. While **doing a tests everything had to be done in the same way**, only **the substance under examination was different**. That means that you applied the “**how to vary one thing at a time**” principle.

**12. Student sheet: Milk, the complete food**

(type 3: experiment-designing version for Group 3 students)

*The first three paragraphs are the same as on the type 1 student sheet (‘step-by-step’ version for Group 1 students), but after that it goes as follows.*

While doing the experiments you will use **tests**. The purpose of these tests in chemistry to **show whether a substance (or group of substances) that has got a certain property is present** in the sample.

A test is good, if the expected change only happens when a **substance (or group of substances)** that has got a certain property is present, and does not happen in any other cases. Therefore you first will do the tests with substances when the test is “**positive**” (i.e. you prove the presence of the given substance). Then you will **compare** the result with the reagent itself, in that the substance (fat, carbohydrate or protein) was not present. While **doing a tests everything had to be done in the same way**, only **the substance under examination was different**. That means that you have to apply the “**how to vary one thing at a time**” principle.

**Experiment 1.a**: Pour water in a test tube to about 4 cm height and add cooking oil to it to about 2 cm height. Use the stopper and shake the content of the test tube vigorously. What do you see?

**Observation:** The water and the oil are **miscible/immiscible**.

**Explanation:** The oil **dissolves in water/fat**, therefore it **separates/does not separate** from water.

Then add petrol to the content of the test tube to about 2 cm height, use the stopper and shake it again. What do you see now?

**Observation:** The water and the petrol are **miscible/immiscible**.

**Explanation:** The oil **dissolves in water/fat**.

Then place 1 drop of oil and 1 drop of petrol (separately, but at the same time) on a piece of filter paper and observe what happens. (Make a sign on the filter paper what substance was dropped where.)

**Observation:** The …………………………………………. evaporated very quickly after dropping the oil and the petrol on

the filter paper, but the …………………………………………….. left a patch on the paper.

**Explanation:** That substance evaporates more quickly of the oil and petrol, in which the interactions among the particles are **stronger/weaker**.

At last place 1 drop of the liquid to the filter paper from the upper layer of the liquid in the test tube. What has happened now?

**Observation:** The sample taken from the upper layer of the content of the test tube left a patch on the paper that is similar to the **oil/petrol**.

**Explanation:** The sample taken from the upper layer of the content of the test tube contained …………………………….

and ……………………….… The …………………………… evaporated, while the …………………………… remained on the paper.

**Experiment 1.b**: Design an experiment to find out whether the milk contains fat. **Apply the** “**how to vary one thing at a time**” **principle while planning** the experiment!

**Plan of the series of experiments**:………………………………………………………….…………………………….………………………………

…………………………………………………………………………………………………………………………………………………………………………….

…………………………………………………………………………………………………………………………………………………………………………….

**Observations**:……………………………………………………………………………………….……………………………………………………………..

…………………………………………………………………………………………………………………………………………………………………………….

**Explanations**:……………………………………………………………………………………………………………………………………....………………

…………………………………………………………………………………………………………………………………………………………………………….

**Experiment 2.a**: Add Fehling’s reagent II drop-by-drop to the Fehling’s reagent I you find in a test tube, until the precipitate that forms in the beginning dissolves with a deep blue colour. Shake the content of the test tube to help the dissolution of the precipitate. Pour one third of the prepared “Fehling reagent” to the glucose solution and heat it in the flame of the burner. What do you see?

**Observation:** A …………………………………….. colour precipitate formed in the test tube containing **glucose**.

**Explanation:** The “Fehling test” that you have just done can be used to show the presence of certain sugars that belong to the carbohydrates (e.g. glucose, lactose and maltose). If the tested liquid contains this type of sugar,

then a …………………………………………….. colour precipitate forms.

**Experiment 2.b**: Design an experiment to find out whether the milk contains carbohydrate. **Apply the** “**how to vary one thing at a time**” **principle while planning** the experiment!

**Plan of experiment**:……………………………………………………………………………….…………………………….………………………………

…………………………………………………………………………………………………………………………………………………………………………….

**Observations**:……………………………………………………………………………………….……………………………………………………………..

…………………………………………………………………………………………………………………………………………………………………………….

**Explanations**:……………………………………………………………………………………………………………………………………....………………

…………………………………………………………………………………………………………………………………………………………………………….

**Experiment 3.a**: Add one third of the sodium hydroxide solution that you find in the test tube to the egg white solution. Then add 5 drops of copper sulphate solution to it. Shake the content of the test tube and observe the colour change.

**Observation:** The content of the test tube containing egg white became …………………………………….. colour.

**Explanation:** The reaction that has taken place is called the “biuret test” that is used for detecting the presence of a certain part of molecules that is characteristic of proteins. The essence of it is that in an alkaline solution the

copper (II) ions form a …………………………………………. colour substance with proteins.

**Experiment 3.b**: Design an experiment to find out whether the milk contains protein. **Apply the** “**how to vary one thing at a time**” **principle while planning** the experiment!

**Plan of experiment**:…………………………………………………………………...………….…………………………….………………………………

…………………………………………………………………………………………………………………………………………………………………………….

**Observations**:……………………………………………………………………………………….……………………………………………………………..

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**Explanations**:……………………………………………………………………………………………………………………………………....………………

…………………………………………………………………………………………………………………………………………………………………………….

Doing the three experiments we have managed to prove that the milk contains …………………………………………………,

……………………………………….. and ………………………………………………. too. While doing the homework, we stated that

vitamins and minerals can also be found in it. According to these, milk is a ………………………………………..food.

**12. Student sheet: Milk, the complete food**

(teacher notes)

Milk has been regarded essential for life, strength and health since the ancient times. The new-born mammals’ (including humans’) first food is milk. Brest milk (mother’s milk) contains especially many different nutrients. Its constitution can change according to the baby’s needs and age. At this lesson you will investigate, whether milk is a complete food. To justify this statement, you have to prove that each type of nutrients can be found in it. While doing your homework, you had a look at the vitamins and minerals that are in the milk. Next we will test for the other nutrients. Each nutrient will be tested by different teams.

Type I. teams will do the Experiment 1, which is the test of fat in milk. Type II. teams will do the Experiment 2, which is the test of sugar in milk. Type III. teams will do the Experiment 3, which is the test of proteins in milk.

After finishing the experiments write down your experiences and the explanations, **underline or frame the correct or cross the not correct parts of the text.** When you are ready, discuss the experiences of each experiment with the other teams and write down the explanations.

[Only for type 1 and 2 student sheets.]

**Experiment 1.a**: Pour water in a test tube to about 4 cm height and add cooking oil to it to about 2 cm height. Use the stopper and shake the content of the test tube vigorously. What do you see?

**Observation:** The water and the oil are **miscible/immiscible.**

**Explanation:** The oil **dissolves in water/fat**, therefore it **separates/does not separate** from water.

Then add petrol to the content of the test tube to about 2 cm height, use the stopper and shake it again. What do you see now?

**Observation:** The water and the petrol are **miscible/immiscible.**

**Explanation:** The oil **dissolves in water/fat**.

Then place 1 drop of oil and 1 drop of petrol (separately, but at the same time) on a piece of filter paper and observe what happens. (Make a sign on the filter paper what substance was dropped where.)

**Observation:** The ***petrol*** evaporated very quickly after dropping the oil and the petrol on the filter paper, but the ***oil*** left a patch on the paper.

**Explanation:** That substance evaporates more quickly of the oil and petrol, in which the interactions among the particles are **stronger/weaker**,.

At last place 1 drop of the liquid to the filter paper from the upper layer of the liquid in the test tube. What has happened now?

**Observation:** The sample taken from the upper layer of the content of the test tube left a patch on the paper that is similar to the **oil/petrol**.

**Explanation:** The sample taken from the upper layer of the content of the test tube contained ***petrol*** and ***oil***. The ***petrol*** evaporated, while the ***oil*** remained on the paper.

**Experiment 1.b**: Pour milk in a test tube to about 4 cm height and add petrol to it to about 2 cm height. Use the stopper and shake the content of the test tube vigorously. What do you see?

**Observation:** ***The content of the test tube separates to two layers.***

**Explanation**: ***The water content and the water soluble (polar) substances of the milk and the petrol plus the (apolar) substances that were extracted by it from the milk separate to two phases. The part that has got the petrol in it is the upper layer, because its density is lower.***

**Experiment 1.c**: Place 1 drop of the upper layer of the liquid being in the test tube containing milk and petrol on a filter paper. Watch what happens for a few minutes!

**Observation:** ***A patch appears on the paper that is similar to that of the oil patch.***

**Explanation**: ***The fat content of the milk dissolves better in the petrol than in the milk that is water-based, therefore fat dissolves in the petrol phase. After the evaporation of petrol the fat remains on the paper.***

**Experiment 2.a**: Add Fehling’s reagent II drop-by-drop to the Fehling’s reagent I you find in a test tube, until the precipitate that forms in the beginning dissolves with a deep blue colour. Shake the content of the test tube to help the dissolution of the precipitate. Pour one third of the prepared “Fehling reagent” to the glucose solution and heat it in the flame of the burner. What do you see?

**Observation:** A ***red*** colour precipitate formed in the test tube containing **glucose**.

**Explanation:** The “Fehling test” that you have just done can be used to show the presence of certain sugars that belong to the carbohydrates (e.g. glucose, lactose and maltose). If the tested liquid contains this type of sugar, then a ***red*** colour precipitate forms.

**Experiment 2.b**: Pour the second third of the prepared “Fehling reagent” to the milk in the test tube and heat it. What do you see? What can you conclude of this?

**Observation:** ***A red precipitate appears in the test tube.***

**Explanation**: ***The milk contains that type of carbohydrate that gives a positive Fehling test. That carbohydrate is called lactose.***

**Experiment 3.a**: Add one third of the sodium hydroxide solution that you find in the test tube to the egg white solution. Then add 5 drops of copper sulphate solution to it. Shake the content of the test tube and observe the colour change.

**Observation:** The content of the test tube containing egg white became ***mauve*** colour.

**Explanation:** The reaction that has taken place is called the “biuret test” that is used for detecting the presence of a certain part of molecules that is characteristic of proteins. The essence of it is that in an alkaline solution the

copper (II) ions form a ***mauve*** colour substance with proteins.

**Experiment 3.b**: Accomplish the biuret test described above with the milk in the test tube. Observe the colour change. What can you conclude from this?

**Observation:** A ***mauve colour appears in the test tube.***

**Explanation**: ***The milk contains proteins.***

Doing the three experiments we have managed to prove that the milk contains ***fat***, ***carbohydrates*** and ***proteins*** too. While doing the homework, we stated that vitamins and minerals can also be found in it. According to these, milk is a ***complete*** food.

[Only for type 2 student sheets.]

While doing the experiments you used **tests**. The purpose of these tests in chemistry to **show whether a substance (or group of substances) that has got a certain property is present** in the sample.

At this lesson you proved the presence of different nutrients (fat, carbohydrate, protein) in the milk. A test is good, if the expected change only happens when a substance (or group of substances) that has got a certain property is present, and does not happen in any other cases. Therefore you first did the tests with substances when the test is “**positive**” (i.e. you proved the presence of the given substance). Then you **compared** the result with the reagent itself, in that the substance (fat, carbohydrate or protein) was not present. Then you applied the tests in the case of the milk too, proving the presence of the given constituent. While **doing a tests everything had to be done in the same way**, only **the substance under examination was different**. That means that you applied the “**how to vary one thing at a time**” principle.

[Only for type 3 student sheets.]

While doing the experiments you will use **tests**. The purpose of these tests in chemistry to **show whether a substance (or group of substances) that has got a certain property is present** in the sample.

A test is good, if the expected change only happens when a **substance (or group of substances)** that has got a certain property is present, and does not happen in any other cases. Therefore you first will do the tests with substances when the test is “**positive**” (i.e. you prove the presence of the given substance). Then you will **compare** the result with the reagent itself, in that the substance (fat, carbohydrate or protein) was not present. While **doing a tests everything had to be done in the same way**, only **the substance under examination was different**. That means that you have to apply the “**how to vary one thing at a time**” principle.

**Experiment 1.a**: Pour water in a test tube to about 4 cm height and add cooking oil to it to about 2 cm height. Use the stopper and shake the content of the test tube vigorously. What do you see?

**Observation:** The water and the oil are **miscible/immiscible.**

**Explanation:** The oil **dissolves in water/ fat**, therefore it **separates/does not separate** from water.

Then add petrol to the content of the test tube to about 2 cm height, use the stopper and shake it again. What do you see now?

**Observation:** The water and the petrol are **miscible/immiscible.**

**Explanation:** The oil **dissolves in water/fat**.

Then place 1 drop of oil and 1 drop of petrol (separately, but at the same time) on a piece of filter paper and observe what happens. (Make a sign on the filter paper what substance was dropped where.)

**Observation:** The ***petrol*** evaporated very quickly after dropping the oil and the petrol on the filter paper, but the ***oil*** left a patch on the paper.

**Explanation:** That substance evaporates more quickly of the oil and petrol, in which the interactions among the particles are **stronger/weaker**,.

At last place 1 drop of the liquid to the filter paper from the upper layer of the liquid in the test tube. What has happened now?

**Observation:** The sample taken from the upper layer of the content of the test tube left a patch on the paper that is similar to the **oil/petrol**.

**Explanation:** The sample taken from the upper layer of the content of the test tube contained ***petrol*** and ***oil*** The ***petrol*** evaporated, while the ***oil*** remained on the paper.

**Experiment 1.b**: Design an experiment to find out whether the milk contains fat. **Apply the** “**how to vary one thing at a time**” **principle while planning** the experiment!

**Plan of the series of experiments**: ***Milk has to be poured in a test tube to about 4 cm height and petrol has to be added to it to about 2 cm height. We have to use the stopper and shake the content of the test tube vigorously. 1 drop of the upper layer of the liquid being in the test tube containing milk and petrol has to be dropped on a filter paper.***

**Observation:** ***The content of the test tube separates to two layers. The petrol is in the upper layer. There is a patch left on the filter paper.***

**Explanation**: ***The water content and the water soluble (polar) substances of the milk and the petrol plus the (apolar) substances that were extracted by it from the milk separate to two phases. The part that has got the petrol in it is the upper layer, because its density is lower.***

***The fat content of the milk dissolves better in the petrol than in the milk that is water-based, therefore the fat dissolves in the petrol phase. After the evaporation of petrol the fat remains on the paper.***

**Experiment 2.a**: Add Fehling’s reagent II drop-by-drop to the Fehling’s reagent I you find in a test tube, until the precipitate that forms in the beginning dissolves with a deep blue colour. Shake the content of the test tube to help the dissolution of the precipitate. Pour one third of the prepared “Fehling reagent” to the glucose solution and heat it in the flame of the burner. What do you see?

**Observation:** A ***red*** colour precipitate formed in the test tube containing **glucose**.

**Explanation:** The “Fehling test” that you have just done can be used to show the presence of certain sugars that belong to the carbohydrates (e.g. glucose, lactose and maltose). If the tested liquid contains this type of sugar, then a ***red*** colour precipitate forms.

**Experiment 2.b**: Design an experiment to find out whether the milk contains carbohydrate. **Apply the** “**how to vary one thing at a time**” **principle while planning** the experiment!

**Plan of experiment**: ***Fehling reagent has to be made in the way it was described in the previous experiment. Then milk has to be added to it to the height of about 6 cm and the content of the test tube has to be heated.***

**Observation:** ***A red precipitate appears in the test tube.***

**Explanation**: ***The milk contains that type of carbohydrate that gives a positive Fehling test. That carbohydrate is called lactose.***

**Experiment 3.a**: Add one third of the sodium hydroxide solution that you find in the test tube to the egg white solution. Then add 5 drops of copper sulphate solution to it. Shake the content of the test tube and observe the colour change.

**Observation:** The content of the test tube containing egg white became ***mauve*** colour.

**Explanation:** The reaction that has taken place is called the “biuret test” that is used for detecting the presence of a certain part of molecules that is characteristic of proteins. The essence of it is that in an alkaline solution the copper (II) ions form a ***mauve*** colour substance with proteins.

**Experiment 3.b**: Design an experiment to find out whether the milk contains protein. **Apply the** “**how to vary one thing at a time**” **principle while planning** the experiment!

**Plan of experiment**: ***We have to pour milk in a test tube about to the height of 4 cm and do the biuret test in the way we learnt it in the previous experiment.***

Doing the three experiments we have managed to prove that the milk contains ***fat***, ***carbohydrates*** and ***proteins*** too. While doing the homework, we stated that vitamins and minerals can also be found in it. According to these, milk is a ***complete*** food.

END OF THE 12. STUDENT SHEETS AND TEACHER NOTES

1. <https://www.youtube.com/watch?v=gOakIi6aKEA> (last visited: 2017. 07. 10.) [↑](#footnote-ref-1)
2. <https://www.youtube.com/watch?v=gOakIi6aKEA> (last visited: 2017. 07. 10.) [↑](#footnote-ref-2)
3. (if the reagent is in excess, as it is in this case). [↑](#footnote-ref-3)
4. (if the reagent is in excess, as it is in this case). [↑](#footnote-ref-4)
5. In the original version of this student sheet two Hungarian idioms are used that are not worth translating into English, since they would not make sense to anybody who does not speak Hungarian. Therefore, this title (suggested and explained by Dr. Réka Borbás) is used instead of them. [↑](#footnote-ref-5)