**STUDENT SHEETS AND TEACHERS GUIDES OF THE FIRST SCHOOLYEAR (2016/2017)**

**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 1: The particle model of matter [1reszecskek\_vilaga2017\_07\_26.docx](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBaXNFIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--f417ebc5c83bf560eb14a6e909f5cdbcd58a284c/1reszecskek_vilaga2017_07_26.docx?disposition=attachment)

Student sheet 2: Physical and chemical properties of matter [2anyagok\_tulajdonsagai\_sutopor2017\_07\_31.docx](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBaXdFIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--9fa6afcac7580cf1d43e6a23c6eff1fe170f095e/2anyagok_tulajdonsagai_sutopor2017_07_31.docx?disposition=attachment)

Student sheet 3: Solubility [3oldodas2017\_07\_27.docx](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBaTBFIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--6f7c5a5111576f3da518aa1f01801ed3559df5de/3oldodas2017_07_27.docx?disposition=attachment)

Student sheet 4: Constitution of solutions [4oldatok\_osszetetele2017\_07\_27.docx](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBaTRFIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--40b3a447cdfb02bdd1309be34db82cd222b1f4e1/4oldatok_osszetetele2017_07_27.docx?disposition=attachment)

Student sheet 5: Separation of mixtures [5keverekek\_szetvalasztasa2017\_07\_28.docx](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBaThFIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--cb085279d9216d2e20c14f04074b9e3d0609c193/5keverekek_szetvalasztasa2017_07_28.docx?disposition=attachment)

Student sheet 6: Identification of materials [6anyagok\_azonositasa2017\_07\_29.docx](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBakFFIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--bef4df614696aeace192558c86b9b5bc1c0b8e49/6anyagok_azonositasa2017_07_29.docx?disposition=attachment)

**1. Student sheet: Our world – the world of particles**

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

Each substance consists of particles which are constantly moving. You are going to investigate what determines how quickly particles move in the gases and liquids. (In solids, they can only vibrate.) Your observation will be explained by the particle model of matter.

**Experiment 1**: a) Each member of your group should measure the time taken for the fragrance particles reach them after being let out/poured out at the teacher's desk. Calculate the average of the times measured by the

group. …………….. minutes.

1. b) Similarly calculate the average distance of your group from the teacher's desk, approx. .......................... m.

1. c) How many meters did the fragrance particles travel in 1 minute? ………...... meters at a speed of ..…m/min.

1. d) Why do you think the speed calculated was not the same for all groups in the class?

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1. e) One particle of oxygen gas travels about 500 meters in 1 second. However, you found that particles moved only a few meters in the air in 1 minute. Can you think of a reason why this happened?

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**Experiment 2**: Pour cold tap water into the plastic bowl. Wait for approx. 5 minutes until the fluid is calm and does not move. Then close to the surface of the water, drop 1 drop of paint solution over the "X" mark and record what is happening. Explain what you see.

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

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

**Experiment 3**: Pour cold water into the bowl to a depth of about 1 cm. Wait for about 5 minutes until the liquid settles. Add 1 drop of paint solution over the "X" mark. When the edge of the paint spot reaches the innermost circle (1st) drawn on the bottom of the tray, start the stopwatch. Measure the time until the particles of the paint reach the 2nd circle, and then after reaching the 3rd circle. Repeat the experiment with warm water. Measure the distance between the 1st and 2nd circles, and the 2nd and 3rd circles with a ruler.

|  |  |  |  |
| --- | --- | --- | --- |
| **Observations:** | **Time** | **Distance** | **Speed of movement** |
| Cold water, between the 1st and 2nd circles | ……. seconds = …... min. | …… cm | …… cm/min. |
| Cold water, between the 2nd and 3rd circles | ……. seconds = …... min. | …… cm | …… cm/min. |
| Warm water, between the 1st and 2nd circles | ……. seconds = …... min. | …… cm | …… cm/min. |
| Warm water, between the 2nd and 3rd circles | ……. seconds = …... min. | …… cm | …… cm/min. |

**The average speed** of the particles **at class level** in **cold** water between circles 1st and 2nd is ............ cm/min.

**The average speed** of the particles **at class level** in **warm** water between circles 1st and 2nd is ........... cm/min.

**Explanation:** Underline the correct word and then complete the sentence.

The particles move in warm water at a **lower/higher** speed than in cold water because

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Why do you think different groups calculated different values for the speed of the particles under the same conditions (e.g. in cold water)?

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4. Based on your experiments, do the particles travel further in **air or in water**? Underline the correct answer. What is the reason of this?

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5. Homework:

a) At a given temperature and if there is nothing in the way, particles of oxygen travel at 461 m/s, particles of nitrogen travel at 492 m/s and particles of hydrogen travel at 1844 m/s between the collisions. What can you conclude of this?

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b) Make a drawing in your notebook or on the back of this worksheet with arrows to show the route of a **particle** (represented by a small circle) in **a gas** as it travels from one wall to the opposite wall.

**1. Student sheet: Our world – the world of particles**

(type 2: ‘step-by-step’ version + theoretical experiment-designing tasks for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but the students also have to solve the tasks below.*

c) If you could mark the particles of water, design an experiment to show that at higher temperatures not only paint particles move faster, but the water particles too. Describe the experiment.

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d) How could you show that particles are moving faster in hot air than in cold air? Describe how you would prepare and carry out the experiment in practice.

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**1. Student sheet: Our world – the world of particles**

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

*Up to this point it is the same than the type 1 student sheet (‘step-by-step’ version for Group 1 students), but it is continued with the experimental design task below.*

**Experiment 3:** Design and carry out an experiment to measure whether the particles move faster in cold water or in hot water. Suitable tools and materials: cold and warm tap water, paint solution, plastic tray, dropper (Pasteur pipette), ruler, permanent marker, stopper (on mobile phone).

Plan of the experiment:

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**Observations and measurement:** …………………………………………………………………………………………………………………………………………………………

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*The remaining part is the same than text following this experiment on the type 1 student sheet (‘step-by-step’ version for Group 1 students).*

**1.** **Student sheet: Our world – the world of particles**

(teacher notes)

Each substance consists of particles which are constantly moving. You are going to investigate what determines how quickly particles move in the gases and liquids. (In solids, they can only vibrate.) Your observation will be explained by the particle model of matter.

**Experiment 1**: a) Each member of your group should measure the time taken for the fragrance particles reach them after being let out/poured out at the teacher's desk. Calculate the average of the times measured by the

group. **E.g. approx. 2.5** minutes.

1. b) Similarly calculate the average distance of your group from the teacher's desk, approx. **5** m.

1. c) How many meters did the fragrance particles travel in **1** minute? 2 meters at a speed of **2** m/min.

1. d) Why do you think the speed calculated was not the same for all groups in the class?

**E.g. we could not measure the distance and time with the same accuracy; not everyone has the same reaction time; our noses are not equally sensitive to that smell; we were moving while we were measuring; in the case of a larger distance, the particles of the fragrance occurred "rarely " in the air.**

1. e) One particle of oxygen gas travels about 500 meters in 1 second. However, you found that particles moved only a few meters in the air in 1 minute. Can you think of a reason why this happened?

**Because of the collisions, the particles went in "zigzag".**

**Experiment 2**: Pour cold tap water into the plastic bowl. Wait for approx. 5 minutes until the fluid is calm and does not move. Then close to the surface of the water, drop 1 drop of paint solution over the "X" mark and record what is happening. Explain what you see.

**Observation**: **The ink slowly spread into the liquid.**

**Explanation**: **The paint and water particles move and mix.**

**Experiment 3**: [Only for type 1 and 2 student sheets.] Pour cold water into the bowl to a depth of about 1 cm. Wait for about 5 minutes until the liquid settles. Add 1 drop of paint solution over the "X" mark. When the edge of the paint spot reaches the innermost circle (1st) drawn on the bottom of the tray, start the stopwatch. Measure the time until the particles of the paint reach the 2nd circle, and then after reaching the 3rd circle. Repeat the experiment with warm water. Measure the distance between the 1st and 2nd circles, and the 2nd and 3rd circles with a ruler.

|  |  |  |  |
| --- | --- | --- | --- |
| **Observations:** | **Time** | **Distance** | **Speed of movement** |
| Cold water, between the 1st and 2nd circles | **125** seconds = **2.1** min. | **1** cm | **0.5** cm/min. |
| Cold water, between the 2nd and 3rd circles | **91** seconds = **1.5** min. | **1** cm | **0.7** cm/min. |
| Warm water, between the 1st and 2nd circles | **22** seconds = **0.4** min. | **1** cm | **2.5** cm/min. |
| Warm water, between the 2nd and 3rd circles | **25** seconds = **0.4** min. | **1** cm | **2.5** cm/min. |

**The average speed** of the particles **at class level** in **cold** water between 1st and 2nd circles is **0,5 - 1** cm/min.

**The average speed** of the particles **at class level** in **warm** water between 1st and 2nd circles is **2-5** cm/min.

**Explanation:** Underline the correct word and then complete the sentence.

The particles move in warm water at a **lower/higher** speed than in cold water because **in the hot water the particles move more intensely ("their energy is higher").**

Why do you think different groups calculated different values for the speed of the particles under the same conditions (e.g. in cold water)?

**For example, because we did not drip the paint solution into the water in the same way, we did not measure the time and distance with the same accuracy, there was a ‘current’ (turbulence) in the fluid during the measurement, the paint particles were not evenly dispersed in the liquid during the measurements.**

**Experiment 3:** [Only for type 3 student sheets.] Design and carry out an experiment to measure whether the particles move faster in cold water or in hot water. Suitable tools and materials: cold and warm tap water, paint solution, plastic tray, dropper (Pasteur pipette), ruler, permanent marker, stopper (on mobile phone).

**Plan of the experiment: For example, it can be similar to one described in the ‘step-by-step’ version, or the time required to travel between two designated points can be measured, or the distance can be measured how far the paint drop can travel in a given time.**

**Observations and measurement: If the temperature of cold and warm water and other conditions are similar, then the speed of the particles obtained should be similar to the ones measured in the the ‘step-by-step’ experiment.**

4. Based on your experiments, do the particles travel further in **air or in water**? Underline the correct answer. What is the reason of this?

**In the air, because the particles in the gases are further apart, therefore they move more easily.**

5. Homework:

a) At a given temperature and if there is nothing in the way, particles of oxygen travel at 461 m/s, particles of nitrogen travel at 492 m/s and particles of hydrogen travel at 1844 m/s between the collisions. What can you conclude of this?

**The reason of the differences can be that the particles are not the same (different in size or weight).**

b) Make a drawing in your notebook or on the back of this worksheet with arrows to show the route of a **particle** (represented by a small circle) in **a gas** as it travels from one wall to the opposite wall.

*Note: In the frame symbolizing the vessel, the circles of the gas particles must be roughly evenly distributed. Straight arrows must indicate the free path length between the two collisions and their direction. Collisions can occur with other particles and the wall of the vessel too. The targeted particle moves not only towards the opposite wall, but also in any other direction (e.g. to the side and even backwards). (If the task is modified in a way that the students need to draw multiple frames, in each frame the location of the surrounding particles must also change, which shows that meanwhile they are moving too.)*

5. c) [Only for type 2 student sheets.] If you could mark the particles of water, design an experiment to show that at higher temperatures not only paint particles move faster, but the water particles too. Describe the experiment.

**It has to be measured that how much time is needed for the particles of water to take the same distance in the water at two different temperatures (or the distance they make within the same time).**

5. d) [Only for type 2 student sheets.] How could you show that particles are moving faster in hot air than in cold air? Describe how you would prepare and carry out the experiment in practice.

**First it has to be measured how much time it takes for the perfume particles to reach a certain distance in the room at the given temperature. The air in the room should then be warmed up (e.g. with a high-power radiator). By operating a fan, it is necessary to ensure that the air temperature is as evenly warm as possible. After stopping the fan, we have to wait for a while to let the air to settle. Then we have to do exactly the same measurement as we did at a lower temperature.**

END OF THE 1. STUDENT SHEETS AND TEACHER NOTES

**2. Student sheet: How does baking powder work?**

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

With the help of chemistry we can change materials into more useful products. To do this, we need to know the nature of the particles and the interactions among them. In physical processes, only the interactions between particles change. During the chemical reactions, the particles also change to form new products. Now you will do experiments to find out about physical and chemical properties, and physical and chemical changes.

**Experiment 1**: Baking powder is a mixture of baking soda, tartaric acid and starch. It is difficult to distinguish between these by simply looking at them. Therefore, you will investigate what happens when we add water, vinegar, iodine solution and red cabbage juice to them. For the four **solids** (baking powder, baking soda, tartaric and starch) place a small heap of each on a white tile. Add a few drops of water and record your observations in the table below. Do the same using vinegar, then iodine solution and finally red cabbage juice.

**Observation:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **↓solids / liquids→** | water | vinegar(acetic acid) | iodine solution | red cabbage juice |
| baking soda |  |  |  |  |
| tartaric acid |  |  |  |  |
| starch |  |  |  |  |
| baking powder |  |  |  |  |

**Explanations:** Underline the right words or complete the text.

(a) Baking soda and tartaric acid are **readily/not very** soluble in water. Starch is **readily/not very** soluble in water. By evaporating the aqueous solution of baking soda and tartaric acid, these solids can be recrystallized so their particles **have changed/did not change** during dissolution. Solubility is therefore a **physical/chemical** property. Dissolving to make a solution is a **physical/chemical** change.

(b) Red cabbage juice in acidic solutions is red coloured, in alkaline solutions it is green and in neutral solutions it has purple colour. Tartaric acid solution is **acidic/alkaline** and the sodium bicarbonate solution is **acidic/alkaline**. Acids and bases react with each other when forming salt and water: **acid + alkali = salt + water**. At this time, **the particles also change** to form different substances (salt and water) from acid and alkali. This is a **physical/chemical** change. Acidity and alkalinity are **physical/chemical** properties. The vinegar is **acidic/basic**, the baking soda is **acidic/basic**.

c) Iodine solution with starch give a ........................................... colour. When heated the iodine/starch solution colour disappears, but reappears when the solution is cooled. The iodine particles **changed/did not change**, the interaction between iodine and starch particles **changed/did not change**. This is a **physical/chemical** change.

**Experiment 2**: When baking powder becomes moist, carbon dioxide gas is produced and helps make the cookie rise. From which two components of baking powder is carbon dioxide gas produced?

Mix the following materials on a white tile: a) baking soda + tartaric acid; b) baking soda + starch; c) tartaric acid + starch. Then drop water on the three small heaps.

**Observation:** There is a fizz only in the case of ................................ + ........................................ .

**Explanation:** The new substance (carbon dioxide) generated by ................................ + ........................................ The particles **changed/did not change** when the gas was formed. This is a **physical/chemical** change.

3. Homework: a) One component of baking powder is not used to make carbon dioxide. What is the purpose of this component? *(Note: An internet link of a website in Hungarian was given in the footnote to help the students to work out the solution.)*

...................................................................................................................................................................................b) At home use some betadine (iodine solution) to test these substances to see if they contain starch: flour, sugar, salt, breadcrumbs, potatoes, sour cream, sausage, rice. Underline the names of which were able to demonstrate the presence of starch.

**2. Student sheet: How does baking powder work?**

(type 2: ‘step-by-step’ version + theoretical experiment-designing tasks for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but the students also have to solve the tasks below.*

c) In the old times some people believed that baking powder is especially effective when it is dissolved in vinegar. Do you think this trick really works? Write down what kind of experiment could prove your idea.

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

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**Expected observations:** ............................................................................................................................................

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

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d) Baking soda is also used to make cakes rise because when it is heated strongly carbon dioxide gas is produced. Design an experiment to support this statement.

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

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**Expected observation: …**……………………………………………………………………………………....................................................

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

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

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**2. Student sheet: How does baking powder work?**

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

*Up to this point it is the same than the type 1 student sheet (‘step-by-step’ version for Group 1 students), but it is continued with the experimental design task below.*

**Experiment 2**: When baking powder becomes moist, carbon dioxide gas is produced and helps make the cookie rise. From which two components of baking powder is carbon dioxide gas produced?

Plan and do an experiment to find it out.

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

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

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

*The remaining part is the same than text following this experiment on the type 1 student sheet (‘step-by-step’ version for Group 1 students).*

**2. Student sheet: How does baking powder work?**

(teacher notes)

With the help of chemistry we can change materials into more useful products. To do this, we need to know the nature of the particles and the interactions among them. In physical processes, only the interactions between particles change. During the chemical reactions, the particles also change to form new products. Now you will do experiments to find out about physical and chemical properties, and physical and chemical changes.

**Experiment 1**: Baking powder is a mixture of baking soda, tartaric acid and starch. It is difficult to distinguish between these by simply looking at them. Therefore, you will investigate what happens when we add water, vinegar, iodine solution and red cabbage juice to them. For the four **solids** (baking powder, baking soda, tartaric and starch) place a small heap of each on a white tile. Add a few drops of water and record your observations in the table below. Do the same using vinegar, then iodine solution and finally red cabbage juice.

**Observation:**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **↓solids / liquids→** | water | vinegar(acetic acid) | iodine solution | red cabbage juice |
| baking soda | **soluble** | **fizzing** | **soluble** | **green, soluble** |
| tartaric acid | **soluble** | **soluble** | **soluble** | **red, soluble** |
| starch | **partly soluble** | **partly soluble** | **dark (blue), partly soluble** | **partly soluble** |
| baking powder | **fizzing** | **fizzing** | **dark (blue)** | **green, fizzing, finally purple/blue** |

**Explanations:** Underline the right words or complete the text.

(a) Baking soda and tartaric acid are **readily/not very** soluble in water. Starch is **readily/not very** soluble in water. By evaporating the aqueous solution of baking soda and tartaric acid, these solids can be recrystallized so their particles **have changed/did not change** during dissolution. Solubility is therefore a **physical/chemical** property. Dissolving to make a solution is a **physical/chemical** change.

(b) Red cabbage juice in acidic solutions is red coloured, in alkaline solutions it is green and in neutral solutions it has purple colour. Tartaric acid solution is **acidic/alkaline** and the sodium bicarbonate solution is **acidic/alkaline**. Acids and bases react with each other when forming salt and water: **acid + alkali = salt + water**. At this time, **the particles also change** to form different substances (salt and water) from acid and alkali. This is a **physical/chemical** change. Acidity and alkalinity are **physical/chemical** properties. The vinegar is **acidic/basic**, the baking soda is **acidic/basic**.

c) Iodine solution with starch give a **dark(blue)** colour. When heated the iodine/starch solution colour disappears, but reappears when the solution is cooled. The iodine particles **changed/did not change**, the interaction between iodine and starch particles **changed/did not change**. This is a **physical/chemical** change.

**Experiment 2**: [Only for type 1 and 2 student sheets.] When baking powder becomes moist, carbon dioxide gas is produced and helps make the cookie rise. From which two components of baking powder is carbon dioxide gas produced?

Mix the following materials on a white tile: a) baking soda + tartaric acid; b) baking soda + starch; c) tartaric acid + starch. Then drop water on the three small heaps.

**Observation:** There is a fizz only in the case of **baking soda** + **tartaric acid**.

**Explanation:** The new substance (carbon-dioxide) generated by **baking soda** + **tartaric acid**.

The particles **changed/did not change** when the gas was formed. This is a **physical/chemical** change.

**Experiment 2**: [Only for type 3 student sheets.] When baking powder becomes moist, carbon dioxide gas is produced and helps make the cookie rise. From which two components of baking powder is carbon dioxide gas produced?

Plan and do an experiment to find it out.

**Plan of the experiment:** **The following materials have to be mixed on a white tile: a) baking soda + tartaric acid; b) baking soda + starch; c) tartaric acid + starch. Then water has to be dropped on the three small heaps.**

**Observation: There is a fizz only in the case of baking soda + tartaric acid.**

**Explanation:** **The new substance (carbon dioxide) generated by baking soda + tartaric acid.**

The particles **changed/did not change** when the gas was formed. This is a **physical/chemical** change.

3. Homework: a) One component of baking powder is not used to make carbon dioxide. What is the purpose of this component? *(Note: An internet link of a website in Hungarian was given in the footnote to help the students to work out the solution.)*

**Answer: Its purpose is absorbing the humidity of the air. This prevents a too early reaction.**

b) At home use some betadine (iodine solution) to test these substances to see if they contain starch: flour, sugar, salt, breadcrumbs, potatoes, sour cream, sausage, rice. Underline the names of which were able to demonstrate the presence of starch.

c) [Only for type 2 student sheets.] In the old times some people believed that baking powder is especially effective when it is dissolved in vinegar. Do you think this trick really works? Write down what kind of experiment could prove your idea.

**Plan of the experiment:** **E.g. A cake should be baked in two different ways: once with the required amount of baking powder and the other time adding vinegar to the baking powder before puting it into the pastry.**

**Expected observation: The second time the cake is flatter than the first one.**

**Explanation:** **Vinegar is acidic, so it can react with baking soda in baking powder. Therefore, only less carbon dioxide gas is produced in the pastry than without the addition of vinegar.**

d) [Only for type 2 student sheets.] Baking soda is also used to make cakes rise because when it is heated strongly carbon dioxide gas is produced. Design an experiment to support this statement.

**Plan of the experiment**: **A small amount of baking soda has to be heated in a testtube. Then a burning wooden splint has to be held into the test tube.**

**Expected observation: The burning wooden splint goes out.**

**Explanation:** **The carbon dioxide gas produced does not fuel combustion.**

END OF THE 2. STUDENT SHEETS AND TEACHER NOTES

**3. Student sheet: Dissolution and bonding**

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

*(Note: The title is a play on words, since the word „oldás” in Hungarian means both dissolution and release, whereas the word „kötés” means not just chemical bonding, but tying or binding too.)*

**Solution** occurs when **the particles of the two mixed substances are similar in nature** and **strong interactions** (**“bondings”**) form between them. We say that **"a substance dissolves well in a similar substance"**. If interactions between the particles of the solution are in total stronger than the interactions among the particles in the two substances being mixed, dissolution results in **heating**, but if they are weaker it results in **cooling**. If **the interactions** among the particles of a substance **are very strong**, then the substance is **insoluble** in most, if not all, substances. This sheet helps you to investigate the **dissolution**.

We meet with solutions every day. Each member of your team should write down the name of a solution.

1. ……………………………………… 2. ……………………………………… 3. ……………………………………… 4. ……………………………………

Every solution consists of solvent and solute. Name the ingredients of the above solutions in the table below.

|  |  |  |
| --- | --- | --- |
| Name of the solution | Name of the solvent | Name(s) of solute(s) |
| 1. |  |  |
| 2. |  |  |
| 3. |  |  |
| 4. |  |  |

**Experiment 1**: In this experiment, you will investigate the solubility of salt, cooking oil and sand in water and in petrol. There is water in the test tubes labelled **1**, **2** and **3** and petrol in the test tubes labelled **4**, **5** and **6**. There is salt on the watch glass labelled **1** and sand on the one labelled **2**. There is cooking oil in the test tube labelled **O**.

a) Place one small spoonful of salt into test tube 1 and into test tube 4.

b) Poor half the oil you find in the "O" test tube into tube 2 and the other half into tube 5.

c) Place half a small spoonful of sand into test tube 3 and and into test tube 6.

Shake the contents of the test tubes. Write your **observations** (dissolve/does not dissolve) into the table below. (The number of test tubes are in brackets.)

|  |  |  |
| --- | --- | --- |
|  | **water** | **petrol** |
| **salt** | (1) | (4) |
| **oil** | (2) | (5)  |
| **sand** | (3) | (6) |

**Explanations:** Read the following text, then **cross** the **not true** parts in the text.

a) Salt **dissolves/does not** **dissolve** in water in test tube 1, because the particles of salt and the particles of water are **similar/not similar**.

Salt **dissolves/does not** **dissolve** in petrol in test tube 4, because the particles of salt and the particles of petrol are **similar/not similar**.

b) Solution **takes place/does not take place** in the case of oil and water in test tube 2 (the two liquids **do not separate/separate**), because the oil and water particles **are similar/not similar**.

Solution **takes place/does not take place** in the case of oil and petrol in test tube 5 (the two liquids **do not separate/separate**), because the oil and petrol particles **are similar/not similar**.

c) The sand does not dissolve in either solvents in test tubes 3 and 6, since it has **very strong/very weak** interactions among its particles. It is **insoluble**.

Substances with particles that can mix with water are called “**water soluble**”, whereas substances that can mix with grease or oil are called “**oil soluble**”. Salt is **water soluble/oil soluble** and petrol is **water soluble/oil soluble**.

**Experiment 2:** Pour half of the alcohol you find in the test tube labelled **A** into the test tube 3 and the other half into test tube 6. Shake the content of the test tubes and write down your **observations**.

Test tube 3: …………………………………………………………………………………………………………………………………………………………

Test tube 6: …………………………………………………………………………………………………………………………………………………………

The particles of the alcohol have got a **water soluble part and an oil soluble part too**. The alcohol has got “**double solubility**”.

**Experiment 3:** There is water in the test tube labelled **W** and petrol in the test tube labelled **P**. Put one or two crystals of iodine in both test tubes from the watch glass labelled 3. Shake the content of the test tubes and write down your **observations**.

Test tube W: ………………………………………………………………………………………………………………………………………………….

Test tube P: …………………………………………………………………………………………………………………………………………………..

**Explanations: Cross** the **not true** parts in the following text.

Iodine dissolves better in **water/petrol**, therefore its particles are more similar to the particles of the **water/petrol**. Iodine is **water soluble/oil soluble.** The particles of iodine make **stronger/weaker** interaction with the particles of water than with the particles of petrol.

**Insert the missing parts** in the following sentences.

Solutions are **mixtures**, because they consist of at least …………………………………………. substances.

The sugar dissolves in water without stirring too, because ……………………………………………………………………………………

**Experiments to be done at home:**

**a) Experiment:** Fill up a glass with cold water in the evening. Let it stand in the warm room for the whole night. Apart from the glass and the water being warmer, what other difference did you notice?

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

What could be the **explanation**? …………………………………………………………………………………………………………………………

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

**b)** **Experiment:** Put a spoonful of washing powder in your hand and add a little bit of water to it. What do you feel, apart from the fact that the material gets silky and slippery?

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

What could be the **explanation**? …………………………………………………………………………………………………………………………

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

**c)** **Experiment:** Put a spoonful of ammonium bicarbonate in your hand and add a little bit of water to it. What do you feel?

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

What could be the **explanation**? …………………………………………………………………………………………………………………………

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

**3. Student sheet: Dissolution and bonding**

(type 2: ‘step-by-step’ version + theoretical experiment-designing tasks for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but the students also have to solve the tasks below.*

**Problem solving tasks:**

**Task 1**: Think of the colours of the two different liquid layers of the gulasch soup. Whether the red paprika powder is water soluble or oil soluble? Design an **experiment** with that you could prove your hypotheses.

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

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

**Expected observation**:…………………………………………………………………………………………………………………………………………

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

**Task 2**: There is a yellow-brown bromine water and a layer of colourless petrol above it in a test tube. We shake the content of the test tube. After a little while the lower layer is colourless and the upper layer is yellow-brown. **Explain** the **observation** of this experiment. (The bromine is the solute in the bromine water.)

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

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**3. Student sheet: Dissolution and binding**

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

*Up to this point it is the same than the type 1 student sheet (‘step-by-step’ version for Group 1 students), but it is continued with the experimental design task below.*

**Experiment 3:** Design and carry out an experiment by using the substances on your tray, by that you can decide whether the **iodine** that you find on the watch glass 3 is **rather water soluble or oil soluble**.

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

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

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

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

**Explnation:** ………………………………………………………………………………………………............................................................

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

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

*The remaining part is the same than text following this experiment on the type 1 student sheet (‘step-by-step’ version for Group 1 students).*

**3. Student sheet: Dissolution and bonding**

(teacher notes)

*(Note: The title is a play on word, since the word „oldás” in Hungarian means both dissolution and release, whereas the word „kötés” means not just chemical bonding, but tying or binding too.)*

**Solution** occurs when **the particles of the two mixed substances are similar in nature** and **strong interactions** (**“bondings”**) form between them. We say that **"a substance dissolves well in a similar substance"**. If interactions between the particles of the solution are in total stronger than the interactions among the particles in the two substances being mixed, dissolution results in **heating**, but if they are weaker it results in **cooling**. If **the interactions** among the particles of a substance **are very strong**, then the substance is **insoluble** in most, if not all, substances. This sheet helps you to investigate the **dissolution**.

We meet with solutions every day. Each member of your team should write down the name of a solution.

1. **lemonade** 2. **tea** 3. **sparkling water** 4. **schnaps**

Every solution consists of solvent and solute. Name the ingredients of the above solutions in the table below.

|  |  |  |
| --- | --- | --- |
| Name of the solution | Name of the solvent | Name(s) of solute(s) |
| 1. **lemonade** | **water** | **sugar, lemon juice** |
| 2. **tea** | **water** | **sugar, substances dissolved from tea leafs** |
| 3. **sparkling water** | **water** | **carbon dioxide** |
| 4. **schnaps** | **water** | **alcohol** |

**Experiment 1**: In this experiment, you will investigate the solubility of salt, cooking oil and sand in water and in petrol. There is water in the test tubes labelled **1**, **2** and **3** and petrol in the test tubes labelled **4**, **5** and **6**. There is salt on the watch glass labelled **1** and sand on the one labelled **2**. There is cooking oil in the test tube labelled **O**.

a) Place one small spoonful of salt into test tube 1 and into test tube 4.

b) Poor half the oil you find in the "O" test tube into tube 2 and the other half into tube 5.

c) Place half a small spoonful of sand into test tube 3 and and into test tube 6.

Shake the contents of the test tubes. Write your **observations** (dissolve/does not dissolve) into the table below. (The number of test tubes are in brackets.)

|  |  |  |
| --- | --- | --- |
|  | **water** | **petrol** |
| **salt** | (1) **dissolves** | (4) **does not dissolve** |
| **oil** | (2) **does not dissolve** | (5) **dissolves** |
| **sand** | (3) **does not dissolve** | (6) **does not dissolve** |

**Explanations:** Read the following text, then **cross** the **not true** parts in the text.

a) Salt **dissolves/does not** **dissolve** in water in test tube 1, because the particles of salt and the particles of water are **similar/not similar**.

Salt **dissolves/does not** **dissolve** in petrol in test tube 4, because the particles of salt and the particles of petrol are **similar/not similar**.

b) Solution **takes place/does not take place** in the case of oil and water in test tube 2 (the two liquids **do not separate/separate**), because the oil and water particles **are similar/not similar**.

Solution **takes place/does not take place** in the case of oil and petrol in test tube 5 (the two liquids **do not separate/separate**), because the oil and petrol particles **are similar/not similar**.

c) The sand does not dissolve in either solvents in test tubes 3 and 6, since it has **very strong/very weak** interactions among its particles. It is **insoluble**.

Substances with particles that can mix with water are called “**water soluble**”, whereas substances that can mix with grease or oil are called “**oil soluble**”. Salt is **water soluble/oil soluble** and petrol is **water soluble/oil soluble**.

Substances that have particles that can mix with water are called “**water soluble**”, whereas substances that can mix with grease or oil are called “**oil soluble**”. Salt is **water soluble/oil soluble** and petrol is **water soluble/oil soluble**.

**Experiment 2:** Pour half of the alcohol you find in the test tube labelled **A** into the test tube 3 and the other half into test tube 6. Shake the content of the test tubes and write down your **observations**.

Test tube 3: **The two liquids do not separate (are mixed). The sand does not dissolve in the mixture.**

Test tube 6: **The two liquids do not separate (are mixed). The sand does not dissolve in the mixture.**

The particles of the alcohol have got a **water soluble part and an oil soluble part too**. The alcohol has got “**double solubility**”.

**Experiment 3:** [Only for type 1 and 2 student sheets.] There is water in the test tube labelled **W** and petrol in the test tube labelled **P**. Put one or two crystals of iodine in both test tubes from the watch glass labelled 3. Shake the content of the test tubes and write down your **observations**.

Test tube W: **The liquid has got a bit yellowish colour. There is undissolved solid in the bottom of the test tube.**

Test tube P: **The liquid is purple. There is no undissolved solid left on the bottom of the test tube.**

**Explanations: Cross** the **not true** parts in the following text.

Iodine dissolves better in **water/petrol**, therefore its particles are more similar to the particles of the **water/petrol**. Iodine is **water soluble/oil soluble.** The particles of iodine make **stronger/weaker** interaction with the particles of water than with the particles of petrol.

**Experiment 3:** [Only for type 3 student sheets.]Design and carry out an experiment by using the substances on your tray, by that you can decide whether the **iodine** that you find on the watchgalss 3 is **rather water soluble or oil soluble**.

**Plan of the experiment:** **If the iodine is oil soluble, than it dissolves in petrol. Therefore approximately the same amount of iodine crystals have to be put in the test tube labelled W than in the test tube labelled P. Both test tubes have to be shaked.**

**Observation: The liquid has got a bit yellowish colour in the test tube W. There is undissolved solid in the bottom of the test tube. The liquid is purple in the test tube P. There is no undissolved solid left on the bottom of the test tube.**

**Explanation: The iodine dissolves better in petrol, therefore its particles are more similar to the particles of the petrol. The iodine is rather oil soluble. The particles of iodine make weaker interaction with the particles of water than with the particles of petrol.**

**Insert the missing parts** in the following sentences.

Solutions are **mixtures**, because they consist of at least **two** substances.

The sugar dissolves in water without stirring too, because **their particles move and can mix with one another.**

**Experiments to be done at home:**

**a) Experiment:** Fill up a glass with cold water in the evening. Let it stand in the warm room for the whole night. Apart from the glass and the water being warmer, what other difference did you notice?

**Observation**: **Little bubbles appear in the liquid.**

What could be the **explanation**? **The gases of the air dissolve better in cold water than in warm water.**

**b)** **Experiment:** Put a spoonful of washing powder in your hand and add a little bit of water to it. What do you feel, apart from the fact that the material gets silky and slippery?

**Observation**: **It feels warm.**

What could be the **explanation**? **This dissolution results in heating.**

**c)** **Experiment:** Put a spoonful of ammonium bicarbonate in your hand and add a little bit of water to it. What do you feel?

**Observation**: **It feels cool.**

What could be the **explanation**? **This dissolution results in cooling.**

**Problem solving tasks:**

**Task 1**: Think of the colours of the two different liquid layers of the gulasch soup. Whether the red paprika powder is water soluble or oil soluble? Design an **experiment** with that you could prove your hypotheses.

**Plan of the experiment**: **The greasy-oily layer on the top of the soup is much more intenesly red than the lower watery layer. Therefore the paprika dissolves better in oil than in water. If the paprika is oil soluble then it dissolves better in petrol than in water. Therefore the same amount of water and petrol or oil has to be poured in two test tubes. About the same amount of paprika should be added to the content of both test tube and then they have to be shaked.**

**Expected observation**: **The solution in petrol or oil is more intensely red than the watery solution.**

**Explanation:** **The particles of the red paparika are more similar to the particles of petrol or oil than to the particles of water. Therfore the red pepper powder is rather oil soluble than water soluble.**

**Task 2**: There is a yellow-brown bromine water and a layer of colourless petrol above it in a test tube. We shake the content of the test tube. After a little while the lower layer is colourless and the upper layer is yellow-brown. **Explain** the **observation** of this experiment. (The bromine is the solute in the bromine water.)

**Bromine can dissolve a little bit in water too, but dissolves much better in petrol. The reason of this is that the particles of bromine are more more similar to the particles of petrol than to the particles of water. Therefore the particles of bromine pass from the water to the petrol after shaking.**

END OF THE 3. STUDENT SHEETS AND TEACHER NOTES

**4. Student sheet: What strength rum is needed for the ‘Gundel’ pancake?**

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

We can use **our knowledge of chemistry to understand, to produce or to affect changes in our everyday life. The composition and concentration of solutions determine their properties,** and therefore **their uses.** Now we will use experiments to investigate the relationship between the composition of alcohol and water mixtures and their flammability. We will practice the **calculations related to the composition of the solutions**.

**1. Experiment**: Wipe the inner side of your wrist with a piece of cotton wool that has been dipped in alcohol. What do you feel?

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

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

Cross the **not true** parts among the **possible choices** on this student sheet.

The evaporation is a change of state that is accompanied by **heating/cooling**.

**2. Experiment**: Pour a little of the 50 per cent by volume alcohol and water mixture into a smaller beaker. Use a pair of tweezers to dip a piece of paper tissue in this solution. Take it out and let the excess liquid drip back into the beaker. Light the match and above a bowl containing sand hold the piece of paper tissue in the flame. Then take it out, put it on the sand and observe the change. Put the extinguished match on the sand too.

**Observation:** The piece of paper that had been dipped into the 50 per cent by volume alcohol and water mixture and held into the flame **ignited/did not ignite** and **keeps burning/is extinguished** when taken out of the flame. The paper is **burnt/is not burnt** by the end of the experiment.

**Explanation:** The **alcohol/water** is the flammable component of the alcohol and water mixture. Burning is a **physical/chemical** **change that releases/absorbs** heat. The paper was not burnt, because the **burning/evaporation** absorbed heat produced during **burning/evaporation**.

**3. Experiment**:Pour the alcohol solution used in experiment 2 into the vessel where you collect the waste. Measure 5 cm3 of 50 per cent by volume alcohol and water mixture into a measuring cylinder and fill it up to the 10 cm3 mark by water. Pour this diluted solution into a smaller beaker and shake it carefully. Dip a dry piece of paper tissue in it and hold it into the flame of a match above the sand bowl for a few moments (after letting the excess of liquid drip back to the beaker) and then put it down on the sand.

**Observation:** The paper dipped into the alcohol solution **ignited/did not ignite**.

**Explanation:** The concentration of the alcohol and water mixture that have been diluted to a double volume is **twice/half** of the 50 per cent by volume alcohol and water solution, therefore it is **………** per cent by volume. The alcohol and water mixture with this composition is **flammable/not flammable**.

**4. Experiment:** Rum is added to the chocolate sauce of the ‘Gundel’ pancake and then it can be ignited at the table. The alcohol content of the rum burns with a lovely blue flame and makes the dish very tasty. Assuming that half of the volume of the chocolate sauce is rum, let’s determine in this experiment the **minimum concentration of the rum** needed so that the chocolate sauce **could be ignited**.

To do so, repeat experiment 3 four times in a way that each time you measure the following volumes of 50 per cent alcohol and water mixture in the measuring cylinder and then dilute them (each time) to 10 cm3.

a) 9 cm3 b) 8 cm3 c) 7 cm3 d) 6 cm3

Each dilution should be done by a different member of your team. Shake the mixture in the beaker each time and try to ignite the piece of paper dipped in it.

**Observation**:

a)………………………………………………………………………. b) …………………………………………………………………………

c)………………………………………………………………………. d) …………………………………………………………………………

**Explanation:** Do these calculations and **fill in** the gaps of the following text.

a) There is 4.5 cm3 alcohol in the 9 cm3 50 per cent by volume alcohol and water solution. The total volume of the solution is 10 cm3. 4.5 cm3 alcohol is $\frac{4,5}{10}×100\%=45\%$ of it. Therefore this solution is ………... per cent by volume.

b) There is …… cm3 alcohol in the 8 cm3 50 per cent by volume alcohol and water solution. The total

volume of the solution is 10 cm3. The …… cm3 alcohol is $\frac{…..}{10}×100\%=…\%$ of it. Therefore this solution is ………... per cent by volume.

c) There is …… cm3 alcohol in the 7 cm3 50 per cent by volume alcohol and water solution. The total

volume of the solution is 10 cm3. The …… cm3 alcohol is $……………………=…\%$ of it. Therefore this solution is ………... per cent by volume.

d) Diluting the 6 cm3 50 per cent by volume alcohol and water mixture with 4 cm3 water, the solution is ……… per cent by volume.

**Consequence:** The alcohol content of the mixture has to be at least ……… per cent by volume, so that it can be ignited. Since half of the volume of the chocolate sauce is rum, the **rum has to contain at least ………… per cent by volume alcohol**.

**Homework:**

**a)** What would happen and why if a piece of paper tissue was dipped into 100 per cent by volume alcohol and after letting the excess of liquid drip off it was held in the flame for a few seconds?

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

**b)** There are several different concentration vinegars in the shops. Why do you think that the mixture containing more than 15 gram of vinegar in a 100 cm3 volume cannot be made by fermentation with bacteria?

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

**4. Student sheet: What strength rum is needed for the ‘Gundel’ pancake?**

(type 2: ‘step-by-step’ version + theoretical experiment-designing tasks for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but the students also have to solve the tasks below.*

**Tasks to think about**

1. Sometimes it is important to know the concentration of a solution. For example 0.9 per cent by mass salt (sodium chloride) solution is used for a saline drip. If the solution was any more or less concentrated it could be dangerous, even lethal. Design an experiment to determine the per cent by mass of salt in a solution.

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

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

**Data** to be measured:……………………………………………………………………………………………………………….……………………...….

Steps of the **calculations**: ……………………………………………………………………………….…………………………………………………….

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

2. The sugar in grapes and other fruits is converted to alcohol by the fungi in the yeast. However, the fungi die if the alcohol content is too high. Plan an experiment to determine what per cent by volume is the maximum alcohol content in which the fungi in the yeast can grow. (The fungi in the yeast can grow well in a dilute solution made of sugar and water. They produce carbon dioxide gas while they grow.)

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

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

Expected **observation**:……………………………………………………………………………………………………………………………………….…

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

**4. Student sheet: What strength rum is needed for the ‘Gundel’ pancake?**

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

*Up to this point it is the same than the type 1 student sheet (‘step-by-step’ version for Group 1 students), but it is continued with the experimental design task below.*

**4. Experiment:** Rum is added to the chocolate sauce of the ‘Gundel’ pancake and then it can be ignited at the table. The alcohol content of the rum burns with a lovely blue flame and makes the dish very tasty. Assuming that half of the volume of the chocolate sauce is rum. Design a series of experiments to determine what is the **minimum concentration of the rum** that we have to buy, so that the chocolate sauce **could be ignited**.

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

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

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

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

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

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

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

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

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

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

Example to do the **calculations**:

There is … cm3 alcohol in the … cm3 50 per cent by volume alcohol and water mixture. The total volume of the

solution is … cm3.

The ………... cm3 alcohol is $\frac{}{}×100\%=.....\%$ of that. Therefore this solution is ………... per cent by volume.

*The remaining part is the same than text following this experiment on the type 1 student sheet (‘step-by-step’ version for Group 1 students).*

**4. Student sheet: What strength rum is needed for the ‘Gundel’ pancake?**

(teacher notes)

We can use **our knowledge of chemistry to understand, to produce or to affect changes in our everyday life. The composition and concentration of solutions determine their properties,** and therefore **their uses.** Now we will use experiments to investigate the relationship between the composition of alcohol and water mixtures and their flammability. We will practice the **calculations related to the composition of the solutions**.

**1. Experiment**: Wipe the inner side of your wrist with a piece of cotton wool that has been dipped in alcohol. What do you feel?

**Observation: Cold/cooling (on the surface of the skin, where it had been wiped with the cotton wool dipped in alcohol).**

**Explanation:** **The evaporation of alcohol absorbs heat from our skin.**

Cross the **not true** parts among the **possible choices** on this student sheet.

The evaporation is a change of state that results in **heating/cooling**.

**2. Experiment**: Pour a little of the 50 per cent by volume alcohol and water mixture into a smaller beaker. Use a pair of tweezers to dip a piece of paper tissue in this solution. Take it out and let the excess liquid drip back into the beaker. Light the match and above a bowl containing sand hold the piece of paper tissue in the flame. Then take it out, put it on the sand and observe the change. Put the extinguished match on the sand too.

**Observation:** The piece of paper that had been dipped into the 50 per cent by volume alcohol and water mixture and held into the flame **ignited/did not ignite** and **keeps burning/is extinguished** when taken out of the flame. The paper is **burnt/is not burnt** by the end of the experiment.

**Explanation:** The **alcohol/water** is the flammable component of the alcohol and water mixture. Burning is a **physical/chemical** **change that releases/absorbs** heat. The paper was not burnt, because the **burning/evaporation** absorbed heat produced during **burning/evaporation**.

**3. Experiment**:Pour the alcohol solution used in experiment 2 into the vessel where you collect the waste. Measure 5 cm3 of 50 per cent by volume alcohol and water mixture into a measuring cylinder and fill it up to the 10 cm3 mark by water. Pour this diluted solution into a smaller beaker and shake it carefully. Dip a dry piece of paper tissue in it and hold it into the flame of a match above the sand bowl for a few moments (after letting the excess of liquid drip back to the beaker) and then put it down on the sand.

**Observation:** The paper dipped into the alcohol solution **ignited/did not ignite**.

**Explanation:** The concentration of the alcohol and water mixture that have been diluted to a double volume is **twice/half** of the 50 per cent by volume alcohol and water solution, therefore it is **25** per cent by volume. The alcohol and water mixture with this composition is **flammable/not flammable**.

**4. Experiment:** [Only for type 1 and 2 student sheets.] Rum is added to the chocolate sauce of the ‘Gundel’ pancake and then it can be ignited at the table. The alcohol content of the rum burns with a lovely blue flame and makes the dish very tasty. Assuming that half of the volume of the chocolate sauce is rum, let’s determine in this experiment the **minimum concentration of the rum** needed so that the chocolate sauce **could be ignited**.

To do so, repeat experiment 3 four times in a way that each time you measure the following volumes of 50 per cent alcohol and water mixture in the measuring cylinder and then dilute them (each time) to 10 cm3.

a) 9 cm3 b) 8 cm3 c) 7 cm3 d) 6 cm3

Each dilution should be done by a different member of your team. Shake the mixture in the beaker each time and try to ignite the piece of paper dipped in it.

**Observations**:

a) **Ignites.** b) **Ignites.**

c) **Ignites/Does not ignite.** d) **Does not ignite.**

*(Note: The observation in case of experiment 4.c depends on the accuracy of the dilution.)*

**Explanation:** Do these calculation and **fill in** the gaps of the following text.

a) There is 4.5 cm3 alcohol in the 9 cm3 50 per cent by volume alcohol and water solution. The total volume of the solution is 10 cm3. 4.5 cm3 alcohol is $\frac{4,5}{10}×100\%=45\%$ of it. Therefore this solution is **45** per cent by volume.

b) There is **4** cm3 alcohol in the 8 cm3 50 per cent by volume alcohol and water solution. The total

volume of the solution is 10 cm3. The **4** cm3 alcohol is $\frac{…4..}{10}×100\%=40\%$ of it. Therefore this solution is **40** per cent by volume.

c) There is **3,5** cm3 alcohol in the 7 cm3 50 per cent by volume alcohol and water solution. The total

volume of the solution is 10 cm3. The **3,5** cm3 alcohol is$\frac{3,5}{10}=35\%$ of it Therefore this solution is **35** per cent by volume.

d) Diluting the 6 cm3 50 per cent by volume alcohol and water mixture with 4 cm3 water, the solution is **30** per cent by volume.

**Consequence:** The alcohol content of the mixture has to be at least **35-40** per cent by volume, so that it can be ignited. Since half of the volume of the chocolate sauce is rum, the **rum has to contain at least 70-80 per cent by volume alcohol**.

**4. Experiment:** [Only for type 3 student sheets.] Rum is added to the chocolate sauce of the ‘Gundel’ pancake and then it can be ignited at the table. The alcohol content of the rum burns with a lovely blue flame and makes the dish very tasty. Assuming that half of the volume of the chocolate sauce is rum. Design a series of experiments to determine what is the **minimum concentration of the rum** that we have to buy, so that the chocolate sauce **could be ignited**.

**Plan of the series of experiments**: *This can be the same as the step-by-step procedure written on the type 1 and 2 student sheets, but it can be different too. For example, the dilutions can be made in a reverse order (starting with the most dilute one and working their way to the most concentrated mixture) or alternating between more dilute and more concentrated solutions or haphazardly trying to find out what the suitable concentration is. The 25 per cent by volume solution made in the experiment 2 could also be used and mixed with the 50 per cent by volume mixture in various proportions. The dilutions could also be made in a way that the final volume is not 10 cm3.*

**Observations**: *According to the plans (see above).*

**Explanations:** *See the experiment 4 on the the type 1 and 2 student sheets.*

Example to do the **calculations,** *e.g.*:

There is **3** cm3 alcohol in the **6** cm3 50 per cent by volume alcohol and water mixture. The total volume of the

solution is **10** cm3.

The ………... cm3 alcohol is $\frac{}{}×100\%=.....\%$ of that. Therefore this solution is ………... per cent by volume.

The **3** cm3 alcohol is $\frac{3}{10}×100\%=30\%$ of that. Therefore this solution is **30** per cent by volume.

**Homework:**

**a)** What would happen and why if a piece of paper tissue was dipped into 100 per cent by volume alcohol and after letting the excess of liquid drip off it was held in the flame for a few seconds?

**The paper tissue ignites in the flame and burns completely when taken out of the flame. This happens, because there is no water in the 100 per cent by volume alcohol. Therefore water cannot absorb the heat generated by the burning of the alcohol. So the paper also warms up to the temperature at that it ignites and then burns completely.**

**b)** There are several different concentration vinegars in the shops. Why do you think that the mixture containing more than 15 gram of vinegar in a 100 cm3 volume cannot be made by fermentation with bacteria?

**The living organisms making the vinegar would die in the too concentrated vinegar solution.**

**Tasks to think about** [Only for type 2 student sheets.]

1. Sometimes it is important to know the concentration of a solution. For example 0.9 per cent by mass salt (sodium chloride) solution is used for a saline drip. If the solution was any more or less concentrated it could be dangerous, even lethal. Design an experiment to determine the per cent by mass of salt in a solution.

Plan of the **experiment**: **The mass of the solution has to be measured.Then the water of the solution should be evaporated. The salt has to be dried (until its mass is constant) and then its mass should be measured.**

**Data** to be measured: **The mass of the solution and the mass of the salt.**

Steps of the **calculations**: **The mass of the salt has to be divided by the mass of the solution and the result should be multiplied by 100.**

2. The sugar in grapes and other fruits is converted to alcohol by the fungi in the yeast. However, the fungi die if the alcohol content is too high. Plan an experiment to determine what per cent by volume is the maximum alcohol content in which the fungi in the yeast can grow. (The fungi in the yeast can grow well in a dilute, lukewarm solution made of sugar and water. They produce carbon dioxide gas while they grow.)

Plan of the **experiment**: **The same amount of yeast and sugar (given in the recipe of a dough) have to be put in similar glasses with different concentration of alcohol and water mixtures. (The latter can be made by dilution from schnaps.) Then the glasses have to be kept at a lukewarm place (e.g. in a lukewarm water bath) for approximately 15-20 minutes.**

Expected **observation**: **There will be glasses in that gas forms, which does not happen in other glasses.**

**Explanation**: **The too high alcohol content in certain glasses kills the microorganisms of the yeast (or at least inhabits their multiplications).**

END OF THE 4. STUDENT SHEETS AND TEACHER NOTES

**5. Student sheet: Let’s help Cinderella…**

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

In the fairy tale about Cinderella, her wicked stepmother made a lot of unnecessary work for her. However, pigeons helped Cinderella to separate the lentil from the inedible ash. The materials found in our environment are mostly **mixtures**. To make them useful, we have to **separate the pure substances**. Sometimes we want to analyse the mixture and identify the pure substances. Separation is usually done using **physical** methods. To do this we must know about the properties of the pure substances and use the differences in the substances’ to separate them from a mixture.

**1. Experiment**: While doing these experiments you will learn about some important separation methods. Carry out the experiments and record your observations and explanations by completing the text, or **crossing** the words that are **not suitable**. You only have to do one of these experiments – following your teacher’s instructions –, the other experiment will be done by the other teams. When you are ready, discuss the observations of all the experiments and write down their explanations too.

**a)** There is a mixture of iron powder and salt in the small glass labelled 1. Pour the mkixture on to a clean sheet of A4 size paper. Cover a magnet with kitchen paper towel and push it into the mixture. Take the paper towel off from the magnet above another clean A4 sheet of paper. Have a look at the residue on the first paper and the collected material on the second paper.

**Experience:** ……..………………………… coloured powder is left behind on the first paper, and this is the

……………………………..…………**.** …………………………………………… coloured powder is on the second paper, and this is the

…………………………………………**.**

**Explanation:** The magnet attracts the…….……………………………………. , but does not attract the

…….………………………………….**.**

**The name of this procedure:** magnetic separation.

**b)** There is a grey powder in the small glass labelled 2. It is a mixture of sand and egg colouring that is used to paint eggs at Easter time. Put 2-3 spoonful of the mixture into a test tube and pour water on it to a depth of about 5 cm. Stopper the test tube and shake its contents thorougly. Wait until the solid material settles to the bottom of the tube and then pour the liquid in a bigger plastic glass. Repeat this two or three times, until you get colourless liquid. Put 2 carbon tablets into the glass and give it to your teacher, who will use this later to do an experiment.

**Experience:** The water was ……………………………………………………… coloured after the first shaking. But its colour

was less and less ……......................................................... after repeating the addition of water.

**Explanation:** The egg colouring………………………………………… in water, the sand ………………………………………

in water. The density of the sand is **lower/higher** than the solution. Therefore the sand collects

………………………………………………… in the test tube.

**The names of these procedures:** extraction, sedimentation and decantation.

**c)** Put the funnel into the test tube and place a previously prepared filter paper or tea filter in it. Put the test tube into the test tube holder. There is a mixture of sulphur and copper sulfate in the small glass labelled 3. Put 2-3 spoonful of this powder in a test tube and pour water on it (to a depth of about 5 cm). Use the stopper to close the test tube and shake its content well. Pour the murky liquid on the filter paper placed in the funnel. When the filtering is done, pour the liquid from the test tube to a bigger glass. Repeat the process once more. Give the bigger glass to your teacher, who will use its content later to do an experiment.

**Experience:** The solution turns to ……………………....… colored after the shaking and …..…....………………….. colored powder is left behind on the paper.

**Explanation:** The blue copper sulphate **dissolves/does not dissolve** in water. The yellow sulphur powder

**dissolves/does not dissolve** in water. Therefore the …….…………………………..…… is left behind on the filter paper

and the …….………………………………………. collects in the solution.

**Name of the procedures:** extraction, filtration.

**d)** There is a brown liquid in the stoppered test tube labelled 1. It is a solution of iodine and green food colouring in alcohol. There is some petrol in the stoppered test tube labelled 2. Pour the petrol in the test tube containing the coloured mixture. Add about the same amount of water, stopper the test tube again and shake the contents well. Put the test tube in the test tube holder and wait for about 2-3 minute.

**Experience:** The liquid slowly separates to ………………………………… parts (layers). The lower part is

…….......................................... coloured, the upper part is ……................................................... coloured.

**Explanation:** The food colouring **dissolves well/does not dissolve** in water, the iodine **dissolves well/does not dissolve** in water, but **dissolves well/does not dissolve** in petrol. The density of water is **higher/lower** than the density of petrol.

**Name of the procedure:** extraction and separation by different density.

**e)** Draw a spot a few millimetre in diameter on the middle of the piece of filter paper using the brown marker (felt pen) and put it on a tile. Put a drop of water on the spot using the plastic pipette and wait a short time. Repeat this a few times. Observe what happens to the coloured spot.

**Experience:** The spot slowly ……..……………………………………………….. on the filter paper. The number of

the coloured circles that are formed from the brown patch is: …..………. The ……………………………………………

coloured circle gets the furthest away.

**Explanationt:** The brown colour of the felt pen is made of ………… components. These are

…………………………………….., ………………………………………..…… and ………………………………………..coloured when they are separated. They look brown when they are mixed together. The

…………………………………………... colouring is bound the least to the filter paper, therefore it gets the **furthest away/the least far** on the filter paper when water is added to it.

**The name of the procedure:** absorption and chromatography.

**2. Experiment: Complex separation experiment**

In the fairy tale about Cinderella, her wicked stepmother deliberately mixed the lentil with ash and other rubbish and then the poor little orphan had to separate the edible lentil from that mixture. An even more wicked stepmother mixed pieces of iron (**1**), copper sulphate (**2**), sand (**3**) and mustard seed (**4**). Instead of the pigeons you should help Cinderella to separate the mixture applying the separation methods you have got known. Using the separation techniques in the right order determined by their physical properties, you can get the components of this mixture. These steps – with the exception of sieving – you did get know while doing the previous experiments. Use the equipment and materials you find on your tray.

**Step 1**: Using the sieve, separate the mustard seed from the other parts of the mixture and put it into a small plastic glass. You should do the sieving above an A4 paper sheet.

**Step 2**: With the help of the magnet wrapped in a paper towel, lift out the pieces of iron from the mixture that is left behind after the previous experiment and put it into another plastic glass.

**Step 3**: Put the residue of the mixture left on the paper in a test tube. Fill it up to about 1/3 with water, close it with a stopper and shake it. Pour the copper sulphate solution into a collecting vessel after waiting for a short while and repeat this once more.

The steps above are summarised on the block diagram below.



**Observations and explanations**

**Step 1:** The mustard seeds can easily be separated from the other components, because of their **bigger/smaller** size, and they are left in the sieve.

**Step 2:** The pieces of iron can be lifted out of the mixture by a magnet, because only the……………………………….. is magnetic of the three remaining components.

**Step 3.:** When the two remaining components are mixed with water a …………………………………………….. coloured solution is formed and the sand sinks to the bottom of the beaker. Only the ………………………………………… dissolves in water, the ………………………………………… is not soluble, and it sinks to the bottom of the beaker because of its **low/high** density.

**Homework after the lesson:**

Some experiments can be made in the kitchen at home, with your parents’ help. Using your mobile phone, take a video of these procedures. Show the videos to your classmates. Discuss with your teacher in advance, how making these experiments will be shared among you.

**a)** Make filtered coffee.

**Observation:** When making the coffee, the ………………………………………… is collected in the cup and the

………………………………………………………….. is left in the filter.

**Explanation:** Some components of the ground coffee are **dissolved/not dissolved** in hot water and they get into the coffee.

**The name of the procedure:** extraction.

**b)** Make fruit juice by using a fruit centrifuge.

**Observation:** The juice of the fruitdrips to the ………………………………………..........................., while the fibres of the fruit remain in the ………………………………………………………………..**.**

**Explanation:** A force acts on the objects in the centrifuge (centrifugal force) **pushing them outwards/pulling them inwards**. The centrifugal force can be **bigger/smaller** than the gravitation force when the revolutions per minute is high enough. The fibres are held back by the sieve of the centrifuge and the liquid is **pushed outwards/pulled inwards** (similarly to what happens in the washing machine).

**The name of the procedure:** centrifuging.

**5. Student sheet: Let’s help Cinderella…**

(type 2: ‘step-by-step’ version + theoretical experiment-designing tasks for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but the students also have to solve the tasks below.*

**Tasks to think about**

**1.** The main components of the stock called ’Vegeta’ are the following: dried vegetable, salt, flavouring that is insoluble in water, food colouring. Think of a plan and write it down in your notebook, which of the methods you have got know could be used to separate those components from one another as best as possible.

**2.** Apart from the components listed above, there is also grease (lard) and oil coming from meat and plants (among other things) in the stock cube. What other separation method (technique) could be used to separate that? Think of your dissolution experiments too. Write down your plan in your notebook.

**5. Student sheet: Let’s help Cinderella…**

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

*Up to this point it is the same than the type 1 student sheet (‘step-by-step’ version for Group 1 students), but it is continued with the experimental design task below.*

**2. Experiment: Complex separation experiment and experiment design**

In the fairy tale about Cinderella, her wicked stepmother deliberately mixed the lentil with ash and other rubbish and then the poor little orphan had to separate the edible lentil from that mixture. An even more wicked stepmother mixed pieces of iron (**1**), copper sulphate (**2**), sand (**3**) and mustard seed (**4**). Instead of the pigeons you should help Cinderella to separate the mixture applying the separation methods you have got known.

Discuss with your groupmates, which separation techniques and in what order should you apply to get the components out of this mixture. Use the equipment and materials you find on your tray. A step of the separation will be needed that there was not among the previous experiments, but knowing the equipment you can find that out easily. Make a block diagram of the necessary steps by writing those in the figure below. Write in the empty fields which component is separated and what separation technique you will use for that. (Use the expressions you have already got know.) Write the numbers of the components left in the mixture in the empty field below it. Discuss you plan with your teacher and do all the steps once he/she agrees. Make note of the observations and explanations.

**The plan of the experiment in a block diagram**



**Observations and explanations:**

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

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

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

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

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

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

*The remaining part is the same than text following this experiment on the type 1 student sheet (‘step-by-step’ version for Group 1 students).*

**5. Student sheets: Let’s help Cinderella…**

(teacher notes)

 *(Note: Since not all separation techniques can be used at the lesson when these student sheets are filled in, a distillation should also be done either at the previous or at the following lesson.)*

In the fairy tale about Cinderella, her wicked stepmother made a lot of unnecessary work for her. However, pigeons helped Cinderella to separate the lentil from the inedible ash. The materials found in our environment are mostly **mixtures**. To make them useful, we have to **separate the pure substances**. Sometimes we want to analyse the mixture and identify the pure substances. Separation is usually done using **physical** methods. To do this we must know about the properties of the pure substances and use the differences in the substances’ to separate them from a mixture.

**1. Experiment**: While doing these experiments you will learn about some important separation methods. Carry out the experiments and record your observations and explanations by completing the text, or **crossing** the words that are **not suitable**. You only have to do one of these experiments – following your teacher’s instructions –, the other experiment will be done by the other teams. When you are ready, discuss the observations of all the experiments and write down their explanations too.

**a)** There is a mixture of iron powder and salt in the small glass labelled 1. Pour the mixture on to a clean sheet of A4 size paper. Cover a magnet with kitchen paper towel and push it into the mixture. Take the paper towel off from the magnet above another clean A4 sheet of paper. Have a look at the residue on the first paper and the collected material on the second paper.

**Experience:** **White** coloured powder is left behind on the first paper, and this is the **salt (sodium chloride).** **Grey** coloured powder is on the second paper, and this is the **iron.**

**Explanation:** The magnet attracts the **iron**, but does not attract the **salt.**

**The name of this procedure:** magnetic separation.

**b)** There is a grey powder in the small glass labelled 2. It is a mixture of sand and egg colouring that is used to paint eggs at Easter time. Put 2-3 spoonful of the mixture into a test tube and pour water on it to a depth of about 5 cm. Stopper the test tube and shake its contents thoroughly. Wait until the solid material settles to the bottom of the tube and then pour the liquid in a bigger plastic glass. Repeat this two or three times, until you get colourless liquid. Put 2 carbon tablets into the glass and give it to your teacher, who will use this later to do an experiment.

**Experience:** The water was **red** coloured after the first shaking. But its colour was less and less **intense** after repeating the addition of water.

**Explanation:** The egg colouring **dissolves** in water, the sand **does not dissolve** in water. The density of the sand is **lower/higher** than the solution. Therefore the sand collects **on the bottom** in the test tube.

**The names of these procedures:** extraction, sedimentation and decantation.

*(Note: The egg colouring could be adsorbed by using active carbon. Since this takes a long time, it could only be finished by the teacher after the present student experiments.)*

**c)** Put the funnel into the test tube and place a previously prepared filter paper or tea filter in it. Put the test tube into the test tube holder. There is a mixture of sulphur and copper sulphate in the small glass labelled 3. Put 2-3 spoonful of this powder in a test tube and pour water on it (to a depth of about 5 cm). Use the stopper to close the test tube and shake its content well. Pour the murky liquid on the filter paper placed in the funnel. When the filtering is done, pour the liquid from the test tube to a bigger glass. Repeat the process once more. Give the bigger glass to your teacher, who will use its content later to do an experiment.

**Experience:** The solution turns to **blue** coloured after the shaking and **yellow** coloured powder is left behind on the paper.

**Explanation:** The blue copper sulphate **dissolves/does not dissolve** in water. The yellow sulphur powder

**dissolves/does not dissolve** in water. Therefore the **sulphur** is left behind on the filter paper and the **cupper sulphate** collects in the solution.

**Name of the procedures:** extraction, filtration.

*(Note: A part of the water could be evaporated from the solution and then some cupper sulfate will appear in the solution after a few days that can be shown to the students. Since this process takes a long time, it could only be finished by the teacher after the present student experiments.)*

**d)** There is a brown liquid in the stoppered test tube labelled 1. It is a solution of iodine and green food colouring in alcohol. There is some petrol in the stoppered test tube labelled 2. Pour the petrol in the test tube containing the coloured mixture. Add about the same amount of water, stopper the test tube again and shake the contents well. Put the test tube in the test tube holder and wait for about 2-3 minute.

**Experience:** The liquid slowly separates to **two** parts (layers). The lower part is **green** coloured, the upper part is **purple** coloured.

**Explanation:** The food colouring **dissolves well/does not dissolve** in water, the iodine **dissolves well/does not dissolve** in water, but **dissolves well/does not dissolve** in petrol. The density of water is **higher/lower** than the density of petrol.

**Name of the procedure:** extraction and separation by different density.

**e)** Draw a spot a few millimetre in diameter on the middle of the piece of filter paper using the brown marker (felt pen) and put it on a tile. Put a drop of water on the spot using the plastic pipette and wait a short time. Repeat this a few times. Observe what happens to the coloured spot.

**Experience:** The spot slowly **spread** on the filter paper. The number of the coloured circles that are formed from the brown patch is: **three.** The **blue** coloured circle gets the furthest away.

**Explanation:** The brown colour of the felt pen is made of **three** components. These are **blue**, **yellow** and **red** coloured when they are separated. They look brown when they are mixed together. The **blue** colouring is bound the least to the filter paper, therefore it gets the **furthest away/the least far** on the filter paper when water is added to it.

**The name of the procedure:** absorption and chromatography.

**2. Experiment: Complex separation experiment** [Only for type 1 and 2 student sheets.]

In the fairy tale about Cinderella, her wicked stepmother deliberately mixed the lentil with ash and other rubbish and then the poor little orphan had to separate the edible lentil from that mixture. An even more wicked stepmother mixed pieces of iron (**1**), copper sulphate (**2**), sand (**3**) and mustard seed (**4**). Instead of the pigeons you should help Cinderella to separate the mixture applying the separation methods you have got known. Using the separation techniques in the right order determined by their physical properties, you can get the components of this mixture. These steps – with the exception of sieving – you did get know while doing the previous experiments. Use the equipment and materials you find on your tray.

**Step 1**: Using the sieve, separate the mustard seed from the other parts of the mixture and put it into a small plastic glass. You should do the sieving above an A4 paper sheet.

**Step 2**: With the help of the magnet wrapped in a paper towel, lift out the pieces of iron from the mixture that is left behind after the previous experiment and put it into another plastic glass.

**Step 3**: Put the residue of the mixture left on the paper in a test tube. Fill it up to about 1/3 with water, close it with a stopper and shake it. Pour the copper sulphate solution into a collecting vessel after waiting for a short while and repeat this once more.

The steps above are summarised on the block diagram below.



**Observations and explanations**

**Step 1:** The mustard seeds can easily be separated from the other components, because of their **bigger/smaller** size, and they are left in the sieve.

**Step 2:** The pieces of iron can be lifted out of the mixture by a magnet, because only the **iron** is magnetic of the three remaining components.

**Step 3.:** When the two remaining components are mixed with water a **light blue** coloured solution is formed and the sand sinks to the bottom of the beaker. Only the **cupper sulphate** dissolves in water, the **sand** is not soluble, and it sinks to the bottom of the beaker because of its **low/high** density.

**2. Experiment: Complex separation experiment and experimental design** [Only for type 3 student sheets.]

In the fairy tale about Cinderella, her wicked stepmother deliberately mixed the lentil with ash and other rubbish and then the poor little orphan had to separate the edible lentil from that mixture. An even more wicked stepmother mixed pieces of iron (**1**), copper sulphate (**2**), sand (**3**) and mustard seed (**4**). Instead of the pigons you should help Cinderella to separate the mixture applying the separation methods you have got known.

Discuss with your groupmates, which separation techniques and in what order should you apply to get the components out of this mixture. Use the equipment and materials you find on your tray. A step of the separation will be needed that there was not among the previous experiments, but knowing the equipment you can find that out easily. Make a block diagram of the necessary steps by writing those in the figure below. Write in the empty fields which component is separated and what separation technique you will use for that. (Use the expressions you have already got know.) Write the numbers of the components left in the mixture in the empty field below it. Discuss you plan with your teacher and do all the steps once he/she agrees. Make note of the observations and explanations.

**The plan of the experiment in a block diagram**



**Observations and explanations:**

**Step 1:** **The mustard seeds can easily be separated from the other components by sieving, because of their size. The mustard seeds is separated from the other part of the mixture above a piece of paper by using the kitchen sieve and they are put into a little plastic glass.**

**Step 2:** **Only the iron is magnetic of the remaining three components. The pieces of iron can be lifted out by using a magnet that is wrapped into a paper towel. The iron is put into another little glass.**

**Step 3:** **Only the cupper sulfute can be dissolved of the remaining mixture. The sand is not soluble in water. The mixture being on the paper is put into a test tube. Water is added to it, the test tube is closed with a stopper and shaked well. Light blue solution is formed and the sand sinks to the bottom of the test tube, because of its high density. We sediment the sand and collect the cupper sulphate solution in a wessel.**

**Homework after the lesson:**

Some experiments can be made in the kitchen at home, with your parents’ help. Using your mobile phone, take a video of these procedures. Show the videos to your classmates. Discuss with your teacher in advance, how making these experiments will be shared among you.

**a)** Make filtered coffee.

**Observation:** When making the coffee, the **coffee** is collected in the cup and the **grounds** is left in the filter.

**Explanation:** Some components of the ground coffee are **dissolved/not dissolved** in hot water and they get into the coffee.

**The name of the procedure:** extraction.

**b)** Make fruit juice by using a fruit centrifuge.

**Observation:** The juice of the fruitdrips to the **glass**, while the fibres of the fruit remain in the **sieve**.

**Explanation:** A force acts on the objects in the centrifuge (centrifugal force) **pushing them outwards/pulling them inwards**. The centrifugal force can be **bigger/smaller** than the gravitation force when the revolutions per minute is high enough. The fibres are held back by the sieve of the centrifuge and the liquid is **pushed outwards/pulled inwards** (similarly to what happens in the washing machine).

**The name of the procedure:** centrifuging.

**Tasks to think about** [Only for type 2 student sheets.]

**1.** The main components of the stock called ’Vegeta’ are the following: dried vegetable, salt, flavouring that is insoluble in water, food colouring. Think of a plan and write it down in your notebook, which of the methods you have got know could be used to separate those components from one another as best as possible.

**We have to dissolve the stock called ’Vegeta’ in water and filter it. The pieces of vegetables remain in the sieve and the water soluble components are in the solution. We can adsorb the colouring substances by active carbon and can crystallize the salts (mainly sodium chloride).**

**2.** Apart from the components listed above, there is also grease (lard) and oil coming from meat and plants (among other things) in the stock cube. What other separation method (technique) could be used to separate that? Think of your dissolution experiments too. Write down you plan in your notebook.

**The grease (lard) and oil coming from meat and plants found in the in the stock cube can be separated (extracted) by using petrol. The water soluble part then can be separated in a way it is done in the case of stock called ’Vegeta’.**

END OF THE 5. STUDENT SHEETS AND TEACHER NOTES

**Preliminary experiments (to be done a prior the 6. student sheets titled „Black, white, yes, no…”)**

*Note: Making these experiments a prior of filling in the student sheets was only necessary, if the students had not seen or done these experiments before.*

**1. preliminary experiment: The colour of the phenolphthalein indicator in different acidic, neutral and alkaline solutions**

Experiment: You have got some labelled white screw caps of plastic bottles. **H** contains dilute hydrochloric acid; **W** containsdistilled water; **S** contains sodium hydroxide solution. Add 1-2 drops of phenolphthalein to each. Record the colour that forms in each. Explain your observations.

Observations:

|  |  |  |  |
| --- | --- | --- | --- |
|  | dilute hydrochloric acid | distilled water | sodium hydroxide solution |
| colour of the phenolphthalein indicator |  |  |  |

Explanation: The colour of the phenolphthalein in acidic and neutral solutions: …………………………………………………,

in alkaline solutions ………………………………………………………….

**2. preliminary experiment: Proving the presence of three colourless and odourless gases by splint**

a) Proving the presence of **carbon dioxide**:

Experiment: Pour half of the dilute hydrochloric acid from the test tube labelled **H** on the limestone in the test tube labelled **L**. (The main component of limestone is calcium carbonate.). The fizzing means a gas is being produced. It is colourless and odourless (which you can prove by careful smelling). Hold a burning splint into the **carbon dioxide** gas.

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

Explanation:………………………………………………………………………………………………………………………………………………………….

b) Proving the presence of **oxygen**:

Experiment: Add the pyrolusit powder you find in the test tube labelled **P** to the hydrogen peroxide solution in the test tube **X**. A colourless and odourless gas is formed that is oxygen. Hold a glowing splint into the **oxygen** gas that formed in the test tube.

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

Explanation:………………………………………………………………………………………………………………………………………………………….

c) Proving the presence of **hydrogen**:

Experiment: Pour the other half of the dilute hydrochloric acid from the test tube labelled **H** into test tube labelled **Mg**, which contains a piece of magnesium. Colourless and odourless **hydrogen** gas forms, filling the test tube. It takes about 1 minute and after this time hold a burning splint to the test tube.

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

Explanation:………………………………………………………………………………………………………………………………………………………….

Write the word equation of the reaction taking place between the hydrogen and the oxygen in the air and/or with symbols:

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

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

**6. Student sheet: Black, white, yes, no…**

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

You probably know the game called “Black, white, yes, no” where the use of these words is forbidden. Now, we invite you to play another game. In that using and extending your knowledge in chemistry, you can observe the characteristics of three black and three white powders and their different behaviours toward other substances. You can experience that the black and white (and the chemistry) is not boring at all. A thorough knowledge of substances can also help when the goal is the identification of an unknown material or the determination of the constituents of a mixture. You can try this field of science – that is called **chemical analysis** – while doing the work described below.

**1. experiment: Black…**

You find the following 3 ‘black’ (actually dark grey) powders on 3 labelled watch glasses: **zinc (Z)**, **graphite (G)** and **iodine (I)**. There is **petrol (P)** in the test tubes closed with stoppers. One by one, add a little bit of all the 3 solids into the 3 test tubes containing petrol. Close the test tubes with the stopper and shake them carefully. There is hydrochloric acid in the open test tube **H**. Add a few drops of hydrochloric acid into 3 wells of the empty medicine pill tray and add a little bit to them (one by one) of the 3 solids. Write your observation into the table below.

**Observations:**

|  |  |  |  |
| --- | --- | --- | --- |
| solid→↓liquid | + zinc (Z) | + graphite (G) | + iodine (I) |
| petrol |  |  |  |
| hydrochloric acid |  |  |  |

**Explanations:** Cross (**this way**) among the words written in bold the ones that should not be there and insert the missing expressions, so that you get the correct text.

The zinc and graphite **can/cannot dissolve** in petrol. The iodine dissolves in petrol **well/poorly** and the result is a ………………………. coloured solution. The dissolution of iodine in petrol is a **physical/chemical** process. The iodine **cannot/poorly/well** dissolve(s) in hydrochloric acid and the graphite **cannot/poorly/well** dissolve(s) in it. The dissolution of zinc in hydrochloric acid is escorted byproduction of…………………………. Therefore there is a substance among the products that is in ………… state at room temperature and its colour is: …………………………………, its smell is: …………………………………… The dissolution of zinc in hydrochloric acid is a **physical/chemical** process. Write the reaction equation in words or by formulae, if you know the essence of this process: …………………………………………………………………………………………………………………………………………………………….

*(Note for the experiment 2: Hydrogen peroxide can be formulated as tablets, these tablets contain a complex with urea. The commercial name in Hungary is Hyperol, further names in other countries are Perhydrit, Sigmafast (TM), One Minute Miracle, Oxygen, Oxysept, Hydro-X, or simply Urea hydrogen peroxide or Perhydrol-urea.)*

**2. experiment: …white,…**

The test tubes contain white powders: **baking soda** in test tube **B;** powdered **Hyperol pill** in test tube **H** and **caustic soda pellets** in test tube **C**. The baking soda (sodium hydrogencarbonate) can be used to treat indigestion as it reacts with the excessive stomach acid. The dilute hydrogen peroxide solution made of the Hyperol pill is used for disinfection because it kills bacteria. The **corrosive** sodium hydroxide that the caustic soda pellets contain that reacts with the materials plugging the sewage pipe.

Do not touch any of the white powders! **Use safety gloves and googles!**

Using distilled water, make 2-3 cm3 solutions of each in separate test tubes. Add a few drops of each solution (one by one) into 3 empty wells of the medicine pill tray and add 2 drops of phenolphthalein indicator to each of them. Add a few drops of each solution (one by one) into another 3 empty wells of the medicine pill tray and add a few drops of hydrochloric acid to each of them. Add a little bit of pyrolusite (manganese dioxide) to the leftovers of the 3 solutions in the test tubes. Write your observation into the table below.

**Observations:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | baking soda solution (sodium hydrogen carbonate solution) | hyperol solution(hydrogen peroxide solution) | caustic soda solution (sodium hydroxide solution) |
| + phenolphthalein |  |  |  |
| + hydrochloric acid |  |  |  |
| + pyrolusite |  |  |  |

**Explanations:** Insert the missing expressions in the text.

The phenolphthalein indicator has …………………………………………… colour in acidic and neutral solution, and it is …………………………………………… colour in alkaline environment. The solution of the …………………………………. and the …………………………..……………………….. of the 3 powders above are alkaline. Adding a few drops of hydrochloric acid to the solutions, we observed fizzing in case of ……….….……………………………………. powder that proves the production of a gas. The colour of the produced gas:…….………………………………………………, and its smell:……………………………………………………… Adding pyrolusite to the solution of the ……………....…………………………………..powder, we experience fizzing. The colour of the produced gas:…….………………………………………………, and its smell:………………………………………………………

**3. experiment: …yes, no?…**

Using your observations from the previous experiments to identify which of the 3 black of white powders you investigated is on the watch glass or in the test tube labelled **unknown (U)** on your tray. You will need to do the same experiments on the unknown powder as you carried out on the same coloured powders and choose to which of their behaviour it behaves similarly.

**Explanations:** Insert the missing expressions in the text.

The unknown …………………………………… coloured powder is the ………………………………………., because……………………………………………………………………………………………………………………………………………………...……………………………………………………………………………………………………………………………………………………

**4. …what did you buy on your money?…**

While doing the experiments, you observed gases forming in three cases (in case of one black and two white powders). In each case the gas produced was colourless and odourless gas. However, the three gases are different. Think of methods how you could identify the three different gases by using a splint. Cross words **that do not suit** into the text and insert the missing expressions.

When hydrochloric acid and zinc react ………………...…………………..gas, when hydrochloric acid and baking soda react ……………………………………… gas is produced. Adding pyrolusite to the solution of ………………………………………, ………………………………………… gas is produced. The **oxygen/carbon dioxide/hydrogen** is not combustible, but it feeds burning, therefore holding a glowing splint in the gas, it …………………………………………………… The **oxygen/carbon dioxide/hydrogen** is not combustible and it does not feed burning, therefore holding a burning splint in the gas, it ………………………………………………….. The **oxygen/carbon dioxide/hydrogen** is combustible, therefore holding a burning splint in the gas, it …………………………………………………………………………………………………

**6. Student sheet: Black, white, yes, no…**

(type 2: ‘step-by-step’ version + theoretical experiment-designing tasks for Group 2 students)

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), but the students also have to solve the tasks below.*

**Tasks to think about**

Name a black and a white powder that you did not use at the lesson and that you could identify by using any physical or chemical process that you know.

Write it down how you design these identifications. (**You must not taste the powders!**)

1. white powder: ……………………………………………………………………………………………………………………………………………….…

The method of identification: ……………………………………………………………………………………………………………….………………

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

2. black powder: ……………………………………………………………………………………………………………………………………………….…

The method of identification: ……………………………………………………………………………………………………………….………………

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

**6. Student sheet: Black, white, yes, no…**

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

**1. Experiment: „Black…”**

You find the following 3 black (actually dark grey) powders on 3 labelled watch glasses: **zinc (Z)**, **graphite (G)** and **iodine (I)**. There is hydrochloric acid in an open test tube (**H**) and **petrol (P)** in the test tube closed with stopper. **Using the two latter reagents** identify which substance is on which watch glass. (You must not use paper to identify the graphite and the smell is not enough to identify the iodine.)

Zinc reacts with hydrochloric acid like the magnesium. There are similarly strong bonds among the particles of graphite than among the particles of sand. Think of the changes that can be observed when the substances to be identified and the reagents meet before starting the experiments and make a “strategic” plan on a separate piece of paper. You can do the experiments with petrol in the empty test tubes closed with stoppers. You can do experiments with the hydrochloric acid in the wells of the empty medicine pill tray. Make notes of your experiences and explain them. The (lucky and clever) group that manages to identify the three powders in the least steps will get a special praise.

**1st step** experiment:……………………………………………………………………….…………………………………………………………………….

Experience:………………………………………………………………………………..………………………………………………………………………..

Explanation:………………………………………………………………………………………………………………………………………………………….

**2nd step** experiment:………………………………………………………………….…………………………………………………………………………

Experience:………………………………………………………………………………..………………………………………………………………………..

Explanation:………………………………………………………………………………………………………………………………………………………….

**3rd** **step** experiment:……………………………………………………………………………………………………………………………………….…….

Experience:………………………………………………………………………………..………………………………………………………………………..

Explanation:………………………………………………………………………………………………………………………………………………………….

**4th** **step** experiment:………………………………………………………………………………………………………………………………….………….

Experience:………………………………………………………………………………..………………………………………………………………………..

Explanation:………………………………………………………………………………………………………………………………………………………….

**2. experiment: „…white,…”**

There are **baking soda (B)**, powdered **Hyperol pill (H)** and **caustic soda pellets (C)** in 3 labelled test tubes. The baking soda (sodium hydrogen carbonate) is suggested against stomach ache, since it reacts with the excessive stomach acid. The dilute hydrogen peroxide solution made of the “Hyperol” pill is used for disinfection, because the forming oxygen kills bacteria. The **corrosive** sodium hydroxide that the caustic soda pellets contain that reacts with the materials plugging the sewage pipe. Do not touch any of the white powders! **Use safety gloves and googles!**

Using distilled water, make solutions of all the 3 powders that are 2-3 cm high in each test tube. How could you determine which test tube contains which substance? There is **phenolphthalein indicator** in the dropper laid on the paper tissue, **hydrochloric acid** in the test tube labelled **H** and **pyrolusite** on the watch glass. Design a series of experiments so that you manage to identify the substances in the **least possible steps**. **Each substance** should be identified by **its characteristic experiment**. Make the experiments when the plan is ready and write down the experiences and the explanations.

**1st step** experiment:……………………………………………………………………….…………………………………………………………………….

Experience:………………………………………………………………………………..………………………………………………………………………..

Explanation:………………………………………………………………………………………………………………………………………………………….

**2nd step** experiment:………………………………………………………………….…………………………………………………………………………

Experience:………………………………………………………………………………..………………………………………………………………………..

Explanation:………………………………………………………………………………………………………………………………………………………….

**3rd** **step** experiment:……………………………………………………………………………………………………………………………………….…….

Experience:………………………………………………………………………………..………………………………………………………………………..

Explanation:………………………………………………………………………………………………………………………………………………………….

**4th** **step** experiment:………………………………………………………………………………………………………………………………….………….

Experience:………………………………………………………………………………..………………………………………………………………………..

Explanation:………………………………………………………………………………………………………………………………………………………….

**5th** **step** experiment:…………………………………………………………………………………………………………………….……………………….

Experience:………………………………………………………………………………..………………………………………………………………………..

Explanation:………………………………………………………………………………………………………………………………………………………….

**6th** **step** experiment:……………………………………………………………………………………………………………………….…………………….

Experience:………………………………………………………………………………..………………………………………………………………………..

Explanation:………………………………………………………………………………………………………………………………………………………….

*The remaining part is the same than text following this experiment on the type 1 student sheet (‘step-by-step’ version for Group 1 students).*

**Preliminary experiments for the 6. students sheets: Black, white, yes, no…**

(teacher notes)

**1. preliminary experiment: The colour of the phenolphtalein indicator in different acidic, neutral and alkaline solutions**

Experiment: You have got some labelled white screw caps of plastic bottles. **H** contains dilute hydrochloric acid; **W** containsdistilled water; **S** contains sodium hydroxide solution. Add 1-2 drops of phenolphthalein to each. Record the colour that forms in each. Explain your observations.

Observations:

|  |  |  |  |
| --- | --- | --- | --- |
|  | dilute hydrochloric acid | distilled water | sodium hydroxide solution |
| colour of the phenophtalein indicator | **colorless** | **colorless** | **purple/pink** |

Explanation: The colour of the phenolphthalein in acidic and neutral solutions: **colourless,** in alkaline solutions **purple/pink**.

**2. preliminary experiment: Proving the presence of three colourless and odourless gases by splint**

a) Proving the presence of **carbon dioxide**:

Experiment: Pour half of the dilute hydrochloric acid from the test tube labelled **H** on the limestone in the test tube labelled **L**. (The main component of limestone is calcium carbonate.). The fizzing means a gas is being produced. It is colourless and odourless (which you can prove by careful smelling). Hold a burning splint into the **carbon dioxide** gas.

Observation: **The burning splint goes out.**

Explanation: **Carbon dioxide does not burn and does not feed burning.**

b) Proving the presence of **oxygen**:

Experiment: Add the pyrolusit powder you find in the test tube labelled **P** to the hydrogen peroxide solution in the test tube **X**. A colourless and odourless gas is formed that is oxygen. Hold a glowing splint into the **oxygen** gas that formed in the test tube.

Observation: **The glowing splint is lit.**

Explanation: **Oxygen is not flammable, but feeds burning.**

c) Proving the presence of **hydrogen**:

Experiment: Pour the other half of the dilute hydrochloric acid from the test tube labelled **H** into test tube labelled **Mg**, which contains a piece of magnesium. Colourless and odourless **hydrogen** gas forms, filling the test tube. It takes about 1 minute and after this time hold a burning splint to the test tube.

Observation: **The gas formed burns with bluish flame and gives a popping noise.**

Explanation: **Hydrogen is flammable.**

Write the word equation of the reaction taking place between the hydrogen and the oxygen in the air and/or with symbols: **hydrogen + oxygen = water** *or* **2 H2 + O2 = 2 H2O**

**6. Student sheets: Black, white, yes, no…**

(teacher notes)

You probably know the game called “Black, white, yes, no” where the use of these words is forbidden. Now, we invite you to play another game. In that using and extending your knowledge in chemistry, you can observe the characteristics of three black and three white powders and their different behaviours toward other substances. You can experience that the black and white (and the chemistry) is not boring at all. A thorough knowledge of substances can also help when the goal is the identification of an unknown material or the determination of the constituents of a mixture. You can try this field of science – that is called **chemical analysis** – while doing the work described below.

**1. experiment: Black…** [Only for type 1 and 2 student sheets.]

You find the following 3 ‘black’ (actually dark grey) powders on 3 labelled watch glasses: **zinc (Z)**, **graphite (G)** and **iodine (I)**. There is **petrol (P)** in the test tubes closed with stoppers. One by one, add a little bit of all the 3 solids into the 3 test tubes containing petrol. Close the test tubes with the stopper and shake them carefully. There is hydrochloric acid in the open test tube **H**. Add a few drops of hydrochloric acid into 3 wells of the empty medicine pill tray and add a little bit to them (one by one) of the 3 solids. Write your observation into the table below.

**Observations:**

|  |  |  |  |
| --- | --- | --- | --- |
| solid→↓liquid | + zinc (Z) | + graphite (G) | + iodine (I) |
| petrol | **does not dissolve** | **does not dissolve** | **dissolves well, pink solution** |
| hydrochloric acid | **dissolve, fizzing** | **does not dissolve** | **dissolves poorly, pale yellow colour** |

**Explanations:** Cross (**this way**) among the words written in bold the ones that should not be there and insert the missing expressions, so that you get the correct text.

The zinc and graphite **can/cannot dissolve** in petrol. The iodine dissolves in petrol **well/poorly** and the result is a **purple/pink** coloured solution. The dissolution of iodine in petrol is a **physical/chemical** process. The iodine **cannot/poorly/well** dissolve(s) in hydrochloric acid and the graphite **cannot/poorly/well** dissolve(s) in it. The dissolution of zinc in hydrochloric acid is escorted byproduction of **bubbles**. Therefore there is a substance among the products that is in **gas** state at room temperature and its colour is: **colourless**, its smell is: **odourless**. The dissolution of zinc in hydrochloric acid is a **physical/chemical** process. Write the reaction equation in words or by formulae, if you know the essence of this process: **zinc + hydrochloric acid = zinc chloride + hydrogen**

*or* **Zn + 2 HCl = ZnCl2 + H2**

*(Note for the experiment 2: Hydrogen peroxide can be formulated as tablets, these tablets contain a complex with urea. The commercial name in Hungary is Hyperol, further names in other countries are Perhydrit, Sigmafast (TM), One Minute Miracle, Oxygen, Oxysept, Hydro-X, or simply Urea hydrogen peroxide or Perhydrol-urea.)*

**2. experiment: …white,…** [Only for type 1 and 2 student sheets.]

The test tubes contain white powders: **baking soda** in test tube **B;** powdered **Hyperol pill** in test tube **H** and **caustic soda pellets** in test tube **C**. The baking soda (sodium hydrogencarbonate) can be used to treat indigestion as it reacts with the excessive stomach acid. The dilute hydrogen peroxide solution made of the Hyperol pill is used for disinfection because it kills bacteria. The **corrosive** sodium hydroxide that the caustic soda pellets contain that reacts with the materials plugging the sewage pipe.

Do not touch any of the white powders! **Use safety gloves and googles!**

Using distilled water, make 2-3 cm3 solutions of each in separate test tubes. Add a few drops of each solution (one by one) into 3 empty wells of the medicine pill tray and add 2 drops of phenolphthalein indicator to each of them. Add a few drops of each solution (one by one) into another 3 empty wells of the medicine pill tray and add a few drops of hydrochloric acid to each of them. Add a little bit of pyrolusite (manganese dioxide) to the leftovers of the 3 solutions in the test tubes. Write your observation into the table below.

**Observations:**

|  |  |  |  |
| --- | --- | --- | --- |
|  | baking soda solution (sodium hydrogen carbonate solution) | Hyperol solution(hydrogen peroxide solution) | caustic soda solution (sodium hydroxide solution) |
| + phenolphthalein | **purple/pink** | **colorless** | **purple/pink** |
| + hydrochloric acid | **fizzing** | **no change** | **no change** |
| + pyrolusite | **no change** | **fizzing** | **no change** |

**Explanations:** Insert the missing expressions in the text.

The phenolphthalein indicator has **colourless** colour in acidic and neutral solution, and it is **purple/pink** colour in alkaline environment. The solution of the **baking soda/sodium bicarbonate** and the **caustic soda pellets /sodium hydroxide** of the 3 powders above are alkaline. Adding a few drops of hydrochloric acid to the solutions, we observed fizzing in case of **baking soda/sodium bicarbonate** powder that proves the production of a gas. The colour of the produced gas: **colourless**, and its smell: **odourless**. Adding pyrolusite to the solution of the **Hyperol** powder, we experience fizzing. The colour of the produced gas: **colourless**, and its smell: **odourless.**

**3. experiment: …yes, no?…**

Using your observations from the previous experiments to identify which of the 3 black of white powders you investigated is on the watch glass or in the test tube labelled **unknown (U)** on your tray. You will need to do the same experiments on the unknown powder as you carried out on the the same coloured powders and choose to which of their behaviour it behaves similarly.

**Explanations:** Insert the missing expressions in the text.

The unknown **balck/dark gray** coloured powder is the **zinc**, because **did not dissolve in petrol and a gas was produced while it reacted with hydrochloric acid**.

*or:*

The unknown **balck/dark gray** coloured powder is the **graphite**, because it **did not dissolve in petrol nor in hydrochloric acid**.

*or:*

The unknown **balck/dark gray** coloured powder is the **iodine**, the because it **dissolved in petrol with purple/pink color and dissolved in hydrochloric acid poorly, with pale yellow color**.

*or:*

The unknown **white** coloured powder is the **baking soda/sodium bicarbonate**, because its **alkaline solution reacted with hydrochloric acid and a gas was produced**.

*or:*

The unknown **white** coloured powder is the **Hyperol**, because its **solution was not alkaline and a gas was produced after adding pyrolusite**.

*or:*

The unknown **white** coloured powder is the **caustic soda pellets/sodium hydroxide**, because **gas was not produced when hydrochloric acid nor when pyrolusite was added to it**.

**4. …what did you buy on your money?…**

While doing the experiments, you observed gases forming in three cases (in case of one black and two white powders). In each case the gas produced was colourless and odourless gas. However, the three gases are different. Think of methods how you could identify the three different gases by using a splint. Cross words **that do not suit** into the text and insert the missing expressions.

When hydrochloric acid and zinc react **hydrogen**.gas, when hydrochloric acid and baking soda react **carbon dioxide** gas is produced. Adding pyrolusite to the solution of **Hyperol**, **oxygen** gas is produced. The **oxygen/carbon dioxide/hydrogen** is not combustible, but it feeds burning, therefore holding a glowing splint in the gas, **lights up**. The **oxygen/carbon dioxide/hydrogen** is not combustible and it does not feed burning, therefore holding a burning splint in the gas, it **goes out.** The **oxygen/carbon dioxide/hydrogen** is combustible, therefore holding a burning splint in the gas, it **it burns with blue flame escorted with a little popping sound**.

**1. Experiment: „Black…”** [Only for type 3 student sheets.]

You find the following 3 black (actually dark grey) powders on 3 labelled watch glasses: **zinc (Z)**, **graphite (G)** and **iodine (I)**. There is hydrochloric acid in an open test tube (**H**) and **petrol (P)** in the test tube closed with stopper. **Using the two latter reagents** identify which substance is on which watch glass. (You must not use paper to identify the graphite and the smell is not enough to identify the iodine.)

Zinc reacts with hydrochloric acid like the magnesium. There are similarly strong bonds among the particles of graphite than among the particles of sand. Think of the changes that can be observed when the substances to be identified and the reagents meet before starting the experiments and make a “strategic” plan on a separate piece of paper. You can do the experiments with petrol in the empty test tubes closed with stoppers. You can do experiments with the hydrochloric acid in the wells of the empty medicine pill tray. Make notes of your experiences and explain them. The (lucky and clever) group that manages to identify the three powders in the least steps will get a special praise.

*Note: The solution described below shows a possible algorithm.*

**Step 1: petrol + sample**

**a) if the solution is purple, then sample 1 is iodine**

**b) if it does not dissolve, sample 1 is either zinc or graphite**

**Step 2: if the sample does not dissolve in petrol, then hydrochloric acid and sample 1**

**a) if it fizzes, then sample 1 is zinc**

**b) if there is no fizz, then sample 1 is graphite**

**Step 3: if sample 1 is iodine, then hydrochloric acid and sample 2**

**a) if it fizzes, then sample 2 is zinc and sample 3 is graphite**

**b) if there is no fizz, then sample 2 is graphite and sample 3 is zinc.**

**2. experiment: „…white,…”** [Only for type 3 student sheets.]

There are **baking soda (B)**, powdered **Hyperol pill (H)** and **caustic soda pellets (C)** in 3 labelled test tubes. The baking soda (sodium hydrogen carbonate) is suggested against stomach ache, since it reacts with the excessive stomach acid. The dilute hydrogen peroxide solution made of the “Hyperol” pill is used for disinfection, because the forming oxygen kills bacteria. The **corrosive** sodium hydroxide that the caustic soda pellets contain that reacts with the materials plugging the sewage pipe. Do not touch any of the white powders! **Use safety gloves and googles!**

Using distilled water, make solutions of all the 3 powders that are 2-3 cm high in each test tube. How could you determine which test tube contains which substance? There is **phenolphthalein indicator** in the dropper laid on the paper tissue, **hydrochloric acid** in the test tube labelled **H** and **pyrolusite** on the watch glass. Design a series of experiments so that you manage to identify the substances in the **least possible steps**. **Each substance** should be identified by **its characteristic experiment**. Make the experiments when the plan is ready and write down the experiences and the explanations.

*Note: The solution described below shows a possible algorithm.*

**Step 1: sample 1 + phenolphthalein**

**a) if the solution is colourless, then sample 1 is Hyperol**

**b) if the solution is purple or pink, then sample 1 is baking soda or caustic soda pellets**

**Step 2: if sample 1 + phenolphthalein is colourless, then the fizz after adding pyrolusite can prove that sample 1 is Hyperol**

**Step 3: if the solution of sample 1 is purple or pink, then sample 1 + hydrochloric acid**

**a) if it fizzes, then sample 1 is baking soda**

**b) if there is no fizz, then sample 1 are caustic soda pellets**

**Step 4: if sample 1 is Hyperol, then sample 2 + hydrochloric acid**

**a) if it fizzes, then sample 2 is baking soda and sample 3 are caustic soda pellets**

**b) if there is no fizz, then sample 2 are caustic soda pellets and sample 3 is baking soda.**

*Note: There was an optional task to help to design the 2. experiment in case of Group 3. In this task the drawings symbolising the logical structure of programmes in informatics (block diagram) were used to illustrate the logic of the solution of an analytical problem. The students could represent their plans applying these. Teachers could explain the meaning of symbols and ask the students to apply it for their own plan. Or the teachers could even print out the possible solutions and give the specific version representing the plan of the team to fill the figure in.*

*Meaning of symbols:*



*An example of the teacher’s version:*



**Tasks to think about** [Only for type 2 student sheets.]

Name a black and a white powder that you did not use at the lesson and that you could identify by using any physical or chemical process that you know.

Write it down how you design these identifications. (**You must not taste the powders!**)

*White powders in the household, e.g.:*

* **Washing powder, identification: dissolves in water, its dissolution results heat.**
* **Powdered sugar, identification: it can be caramelised while heated.**
* **Salt volatile, identification: it dissolves in water and fizzes after adding acid to it.**
* **Flour, identification: it does not dissolve in cold water, only forms size. It partly dissolves in warm water and forms an opalescent solution.**
* **Salt, identification: It dissolves in water. It makes the flame of the cooker yellow when it gets to it.**

*Black powders in the household, e.g.:*

* **The filling of the fridge deodorizer, identification: It does not dissolve in either water or acid. It looks like powdered carbon.**
* **Carbon tablet, identification: It does not dissolve in either water or acid. It looks like carbon.**

END OF THE 6. STUDENT SHEETS AND TEACHER NOTES