**STUDENT SHEETS AND TEACHERS GUIDES OF THE FORTH SCHOOL YEAR (2019/2020)**

**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 19: **Crystal-ball gazing or forecast?** [19. feladatlap: Jóslás vagy előrejelzés?](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBZ1lLIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--f00e3cef7b906d9e579a346e133b3b08f6413f69/19MTAJoslas_hlg_reakciok2021_01_17HONLAPRA.docx?disposition=attachment)

Student sheet 20: **A blessing or a curse is the plastic?** [20. feladatlap: Áldás vagy átok a műanyag?](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBZ2NLIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--b9c34996b959e5f23a24989d39b9eb68e8be7dbe/20Muanyag2021_01_18_HONLAPRA.docx?disposition=attachment)

Student sheet 21: **La dolce vita – Sweet life** [21. feladatlap: La dolce vita – Az édes élet](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBdVFKIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--53e1cd77eeb00c8878593fb771ec3915fa487c18/21_La%20dolce_vita2019_09_03NYOMTATNI.docx?disposition=attachment)

Student sheet 22: **Can you E-at it?** [22. feladatlap: Megeheted-„E”?](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBZ2dLIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--0f818280f7422d5eecf62b29ab0ef7e91ce76f74/22MegehetedE_2021_01_18_HONLAPRA.docx?disposition=attachment)

Student sheet 23: **How much vitamin C is in the orange juice?** [23. feladatlap: Mennyi a C-vitamin a narancslében?](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBdVlKIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--9f85be16af2512b4cc51b165c52b27baf34580b3/23Narancsle_C_vitamin2019_09_20_NYOMTATNI.doc?disposition=attachment)

Student sheet 24: **Poisons, stakes, models…** [24. feladatlap: Mérgek, máglyák, modellek...](http://ttomc.elte.hu/rails/active_storage/blobs/eyJfcmFpbHMiOnsibWVzc2FnZSI6IkJBaHBBdWNKIiwiZXhwIjpudWxsLCJwdXIiOiJibG9iX2lkIn19--c838b6ca662d1c01f87b88002f74f8ce1f126f81/24_Feherjek_2019_09_11_NYOMTATNI.docx?disposition=attachment)

**19. Student sheet:**

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

Even the ancient Greeks wanted to know the future. Therefore, for more than a thousand years, the priests and priestesses of the prophecy of Delphi made a good living from their nearly always uncertain, and sometimes downright incomprehensible, prophecies. There were often fortune tellers in the courts of the kings of antiquity and the Middle Ages. For example, they sought (non-existing) logical connections between the shape of animal intestines or the orbit of stars and future military or other events. (However, if they were fair and smart enough, they also recognized real patterns. Such as Kepler's laws, which still fundamentally describe the movement of celestial bodies.) There is still a need to learn about the future today, and unfortunately rogues can spread a lot on the Internet. With a little family tree research (done in internet databases), some knowledge about human nature, minimal inference, and without any conscience, you can still do well today with fortune telling from cards or palmistry… Scientists also often make predictions. However, they are constructed on the basis of logical and real relationships, the existence of which has been regularly and consistently confirmed by the experience of observations and experiments. We see some examples of this in this lesson.

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

**Demonstration (teacher experiment):** *This experiment can only be performed with the quantities given here and under a well-functioning fume cupboard or on the windowsill of an open window!* In a small beaker, pour 2 volumes (maximum 20 cm3) of household hypochlorite (*w*≤5% sodium hypochlorite solution). Add little by little and gently(!) stirring the solution from time to time 1 volume (maximum 10 cm3) of household hydrochloric acid (*w* = 5-10 %) or liquid limescale solvent. *Do not breathe near the solution!*

**Experience:** …………………………………………………………………………………………………………………………………………………………

**Explanation:** Chemical reactions produce …………………………………. gas. Write down the sum of these reaction

equations! ................................................................................................................................................................

The ………………………………. gas is TOXIC! Therefore, DO NOT use acidic substances with chemicals containing

hypochlorite. The ……………………………. gas is poorly soluble in water physically, because the …………………………….

molecules are apolar, the …………………………….. molecules are polar. However, the …………………………….. gas also

dissolves in water chemically, according to the following equation:

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

This is a chemical equilibrium that gradually shifts to the **right / left** as the ………………………….…… gas escapes.

**1. Experiment**: Sprinkle some potassium bromide in chlorinated water, then pour a little gasoline into the test tube and shake.

**Experience:** …………………………………………………………………………………………………………………………………………………………

**Explanation:** A reaction **has / has not** occurred. What shows if a reaction has taken place?

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

If a reaction has taken place, write down the reaction equation as well.

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

**2. Experiment**: Sprinkle some potassium iodide in brominated water, then pour a little gasoline into the test tube and shake.

**Experience:** …………………………………………………………………………………………………………………………………………………………

**Explanation:** A reaction **has / has not** occurred. What shows if a reaction has taken place?

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

If a reaction has taken place, write down the reaction equation as well.

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

**3. Experiment** Sprinkle some potassium chloride into the iodinated water, then pour a little gasoline into the test tube and shake.

**Experience:** …………………………………………………………………………………………………………………………………………………………

**Explanation:** A reaction **has / has not** occurred. What shows if a reaction has taken place?

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

If a reaction has taken place, write down the reaction equation as well.

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

**19. Student sheet:**

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

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

The knowledge acquired and systematized by researchers can be learned from the literature. It is not worth tackling any of the problems without looking at what results have been published by experts in the field in the past. Based on the data in the literature, we can make hypotheses and well-founded assumptions. In the above experiments, for example, the electronegativity values found in the periodic table can be used to predict which reaction can occur and which cannot. To test the hypotheses, we can design experiments and compare their experiences with prior knowledge. You did exactly the latter in explaining the experiments. The results of recent research can only be included in the literature if it is known, discussed and found worthwhile by experts working in the given field. This process thus distinguishes the work of scientists from the hocus-pocus of the fortune tellers.

**19. Student sheet:**

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

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), except the student experiments part and the last paragraph that go as follows.*

Whether a halogen element reacts with another halogen salt (halide ion) can be predicted with complete certainty. This is because it depends on which halogen is able to attract electrons more strongly. What is the concept called that characterizes how much the bonded atom can attract electron?

…………………………………………………… How does this change in the groups of the periodic table from top to bottom?

………………………………………………Why? …………………………………………………………………………………………………………………..

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Aqueous solutions of halogen elements (chlorine, bromine and iodine) as well as solid halide salts (KCl, KBr, KI) can be found on the trays. Now it is your job to plan two experiments. **In Experiment 1, a reaction takes place** between the halogen element and the halide ion. **In Experiment 2, no reaction should occur** between the halogen element and the halide ion. There are no empty test tubes, so you can only use each solution once. To predict the results of the experiments, use the data of the periodic table as a literature source! For example, discuss whether there is a reaction between brominated water (halogen: Br2) and potassium iodide (halide ion: I-) and why.

Elemental bromine (brominated water) and elemental iodine (iodinated water) dissolved in water have very similar color, depending on their concentration. There is another substance on your trays that you can use to decide whether elemental bromine or elemental iodine is present. What is the substance?

…………………………………………… Why can it be used for this purpose?

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

What is the polarity of these materials and how does it affect their solubility?

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

**Plan of Experiment 1 (reaction takes place):** ………………………………………………………………………………………………………..

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

**Experience**: …………………………………………………………………………………………………………………………………………………………

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**Explanation**: How can you tell that a reaction has occurred? ……………………………….……………………………………………….

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

Reaction equation: …………………………………………………………………………………………………………………………………….…………

The ………………………….. oxidized the ………………………….., i.e. **it took an electron from it / gave off** **an electron to it.** Why did the reaction occur?

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

**Plan of Experiment 2 (no reaction occurs):** ………………………………………………………………………………………………………..

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

**Experience**: …………………………………………………………………………………………………………………………………………………………

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**Explanation**: Why does it not occur? ……………………………….…………………………………………………………………………………..

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

How can you tell that it has not occurred? …………………………………………………………………………………………………………….

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

Thus, an elemental halogen molecule is able to **oxidize / reduce** the anion (halide ion) of another halogen if the elemental halogen attracts electrons **more / less** than the halide ion. How much a bound atom can attract

electrons, is shown by the ……………………………………………………………………………… value that can be read from the

periodic table. A halogen with **smaller / larger** ……………………………………………………………………………. that is located **higher / lower** in the periodic table, can oxidize the anion of the other halide salt. Based on this, it can be predicted with 100% confidence whether a reaction between a halogen and another halide will take place. Unlike, for example, whether we will win the lottery this week if we play… 😊

The knowledge acquired and systematized by researchers can be learned from the literature. It is not worth tackling any of the problems without looking at what results have been published by experts in the field in the past. Based on the data in the literature, we can make hypotheses and well-founded assumptions. In the above experiments, for example, the electronegativity values found in the periodic table can be used to predict which reaction can occur and which cannot. To test the hypotheses, we can design experiments and compare their experiences with prior knowledge. You did exactly the latter in explaining the experiments. The results of recent research can only be included in the literature if it is known, discussed and found worthwhile by experts working in the given field. This process thus distinguishes the work of scientists from the hocus-pocus of the fortune tellers.

**19. Student sheet:**

(teacher notes)

Even the ancient Greeks wanted to know the future. Therefore, for more than a thousand years, the priests and priestesses of the prophecy of Delphi made a good living from their nearly always uncertain, and sometimes downright incomprehensible, prophecies. There were often fortune tellers in the courts of the kings of antiquity and the Middle Ages. For example, they sought (non-existing) logical connections between the shape of animal intestines or the orbit of stars and future military or other events. (However, if they were fair and smart enough, they also recognized real patterns. Such as Kepler's laws, which still fundamentally describe the movement of celestial bodies.) There is still a need to learn about the future today, and unfortunately rogues can spread a lot on the Internet. With a little family tree research (done in internet databases), some knowledge about human nature, minimal inference, and without any conscience, you can still do well today with fortune telling from cards or palmistry… Scientists also often make predictions. However, they are constructed on the basis of logical and real relationships, the existence of which has been regularly and consistently confirmed by the experience of observations and experiments. We see some examples of this in this lesson.

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

**Demonstration (teacher experiment):** *This experiment can only be performed with the quantities given here and under a well-functioning fume cupboard or on the windowsill of an open window!* In a small beaker, pour 2 volumes (maximum 20 cm3) of household hypochlorite (*w*≤5% sodium hypochlorite solution). Add little by little and gently(!) stirring the solution from time to time 1 volume (maximum 10 cm3) of household hydrochloric acid (*w* = 5-10 %) or liquid limescale solvent. *Do not breathe near the solution!*

**Experience:** **Bubble formation, the solution turns yellow-green in color, a pungent odor is felt.**

**Explanation:** Chemical reactions produce **chlorine** gas. Write down the sum of these reaction equations!

**NaOCl + 2HCl = Cl2 + NaCl + H2O**

The **chlorine** gas is TOXIC! Therefore, DO NOT use acidic substances with chemicals containing hypochlorite. The **chlorine** gas is poorly soluble in water physically, because the **chlorine** molecules are apolar, the **water** molecules are polar. However, the **chlorine** gas also dissolves in water chemically, according to the following equation:

**Cl2 + H2O ⇌ HCl + HOCl**

This is a chemical equilibrium that gradually shifts to the **right / left** as the **chlorine** gas escapes.

[Only for type 1 and 2 student sheets.]

**1. Experiment**: Sprinkle some potassium bromide in chlorinated water, then pour a little gasoline into the test tube and shake.

**Experience:** **The lower phase is lighter yellowish (brown) and the upper phase is darker brown.**

**Explanation:** A reaction **has / has not** occurred. What shows if a reaction has taken place? **Bromine dissolves in gasoline with a brown color.** If a reaction has taken place, write down the reaction equation as well.

**Cl2 + 2KBr = 2KCl + Br2**

**2. Experiment**: Sprinkle some potassium iodide in brominated water, then pour a little gasoline into the test tube and shake.

**Experience:** **The lower phase is brown and the upper phase is purple.**

**Explanation:** A reaction **has / has not** occurred. What shows if a reaction has taken place? **Iodine dissolves in gasoline with a purple color.** If a reaction has taken place, write down the reaction equation as well.

**Br2 + 2 KI = 2 KBr + I2**

**3. Experiment** Sprinkle some potassium chloride into the iodinated water, then pour a little gasoline into the test tube and shake.

**Experience:** **The lower phase is brown and the upper phase is purple.**

**Explanation:** A reaction **has / has not** occurred. What shows if a reaction has taken place? **Iodine dissolves in gasoline with a purple color.** If a reaction has taken place, write down the reaction equation as well. **The reaction did not take place.**

[Only for type 3 student sheets.]

*It is the same as the type 1 student sheet (‘step-by-step’ version for Group 1 students), except the student experiment part and the last paragraph that go as follows.*

Whether a halogen element reacts with another halogen salt (halide ion) can be predicted with complete certainty. This is because it depends on which halogen is able to attract electrons more strongly. What is the concept called that characterizes how much the bonded atom can attract electron? **Electronegativity (EN).** How does this change in the groups of the periodic table from top to bottom? **Decreases.** Why? **Because the outermost electrons in the group are further and further away from the nucleus.**

Aqueous solutions of halogen elements (chlorine, bromine and iodine) as well as solid halide salts (KCl, KBr, KI) can be found on the trays. Now it is your job to plan two experiments. **In Experiment 1, a reaction takes place** between the halogen element and the halide ion. **In Experiment 2, no reaction should occur** between the halogen element and the halide ion. There are no empty test tubes, so you can only use each solution once. To predict the results of the experiments, use the data of the periodic table as a literature source! For example, discuss whether there is a reaction between brominated water (halogen: Br2) and potassium iodide (halide ion: I-) and why.

Elemental bromine (brominated water) and elemental iodine (iodinated water) dissolved in water have very similar color, depending on their concentration. There is another substance on your trays that you can use to decide whether elemental bromine or elemental iodine is present. What is the substance? **Gasoline.** Why can it be used for this purpose? **Because bromine dissolves with brown and iodine with purple color in it.**

What is the polarity of these materials and how does it affect their solubility? **Halogen molecules are apolar and therefore more soluble in apolar gasoline than in polar water.**

**Plan of Experiment 1 (reaction takes place):** *(Possible solutions.)*

**a) Potassium bromide is sprinkled into the chlorinated water in a test tube, then a little gasoline is added and shaken.**

**b) Potassium iodide is sprinkled into the chlorinated water in a test tube, then a little gasoline is added and shaken.**

**c) Potassium iodide is sprinkled into the brominated water in a test tube, then a little gasoline is added and shaken.**

**Experience**: *(Possible experiences.)*

**a) The lower phase is lighter yellowish (brown) and the upper phase is darker brown.**

**b) The lower phase is brown and the upper phase is purple.**

**c) The lower phase is brown and the upper phase is purple.**

**Explanation**: *(In the cases of the possible solutions.)* How can you tell that a reaction has occurred?

**a)** **Bromine dissolves in gasoline with a brown color.** Reaction equation: **Cl2 + 2KBr = 2KCl + Br2**

The **chlorine** oxidized the bromide ion, i.e. it **took an electron from it** / gave off an electron to it. Why did the reaction occur? ***EN*(Cl) >*EN*(Br)**

**b**) **Iodine dissolves in gasoline with a purple color.** Reaction equation: **Cl2 + 2 KI = 2 KCl + I2**

The **chlorine** oxidized the ioide ion, i.e. it **took an electron from it** / gave off an electron to it. Why did the reaction occur? ***EN*(Cl) >*EN*(I)**

**c**) **Iodine dissolves in gasoline with a purple color.** Reaction equation: **Br2 + 2 KI = 2 KBr + I2**

The **bromine** oxidized the ioide ion, i.e. it **took an electron from it** / gave off an electron to it. Why did the reaction occur? ***EN*(Br) >*EN*(I)**

**Plan of Experiment 2 (no reaction occurs):** *(Possible solutions.)*

**d) Potassium chloride is sprinkled into the brominated water in a test tube, then a little gasoline is added and shaken.**

**e) Potassium chloride is sprinkled into the iodinated water in a test tube, then a little gasoline is added and shaken.**

**c) Potassium bromide is sprinkled into the iodinated water in a test tube, then a little gasoline is added and shaken.**

**Experience**: *(Possible experiences.)*

**d) The lower phase is lighter yellowish (brown) and the upper phase is darker brown.**

**e) The lower phase is brown and the upper phase is purple.**

**f) The lower phase is brown and the upper phase is purple.**

**Explanation**: *(These reactions do not take place.)*

**d)** Why does it not occur? ***EN*(Cl) >*EN*(Br)** How can you tell that it has not occurred? **The brownish color of the bromine did not disappear. (The yellowish-green color of the chlorine did not appear).**

**e)** Why does it not occur? ***EN*(Cl) >*EN*(I)** How can you tell that it has not occurred? **The brown color of the iodine did not disappear in the aqueous phase, in fact the upper (gasoline) phase became purple from the elemental iodine. (The yellowish-green color of the chlorine did not appear.)**

**f)** Why does it not occur? ***EN*(Br) >*EN*(I)** How can you tell that it has not occurred? **The brown color of the iodine did not disappear in the aqueous phase, in fact the upper (gasoline) phase became purple from the elemental iodine. (The brown color of the bromine did not appear in the gasoline.)**

[For all type student sheets.]

Thus, an elemental halogen molecule is able to **oxidize / reduce** the anion (halide ion) of another halogen if the elemental halogen attracts electrons **more / less** than the halide ion. How much a bound atom can attract electrons, is shown by the **electronegativity (*EN*)** value that can be read from the periodic table. A halogen with **smaller / larger** **electronegativity** that is located **higher / lower** in the periodic table, can oxidize the anion of the other halide salt. Based on this, it can be predicted with 100% confidence whether a reaction between a halogen and another halide will take place. Unlike, for example, whether we will win the lottery this week if we play… 😊

[Only for type 2 and 3 student sheets.]

The knowledge acquired and systematized by researchers can be learned from the literature. It is not worth tackling any of the problems without looking at what results have been published by experts in the field in the past. Based on the data in the literature, we can make hypotheses and well-founded assumptions. In the above experiments, for example, the electronegativity values found in the periodic table can be used to predict which reaction can occur and which cannot. To test the hypotheses, we can design experiments and compare their experiences with prior knowledge. You did exactly the latter in explaining the experiments. The results of recent research can only be included in the literature if it is known, discussed and found worthwhile by experts working in the given field. This process thus distinguishes the work of scientists from the hocus-pocus of the fortune tellers.

END OF THE 19. STUDENT SHEETS AND TEACHER NOTES

**20. Student sheet:**

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

**Underline or frame the correct or cross the not correct parts of the text before or after the / sign.**

Just imagine what would stay in your homes, in the street, at school, if any object disappeared that has got plastic in it! However, hundreds of thousands of bottles are being collected on the Tisza as part of the PET Cup… Many photos can also be seen on the internet of dead animals whose deaths were caused by various plastics. And in one liter of snow (melted) falling in the North Pole, which is thought to be the cleanest, more than ten thousand plastic particles smaller than five micrometers were found. So plastic**: blessing / curse / both at once**.

To reduce the problems, the “**5R**” approach is internationally accepted: **R**euse; **R**educe; **R**ecycle; **R**ethink; **R**estore. There are plenty of types of plastic. To understand how they can be used and what we can do with them when we no longer need them, it is good to learn about the chemical background of their production, properties, and disposal.

The names and ideas used in everyday life in connection with plastics are sometimes inaccurate and even misleading. For example, the materials of a plastic bag that in Hungarian is referred as a “nylon” bag and “nylon stockings” belong to two completely different groups of plastics. According to their production method, **polymerization** type plastics, i.e. **polyaddition** plastics, are formed by the bonding of unsaturated (double-bonded) monomers without by-products. In the case of **polycondensation** plastics, on the other hand, small molecules such as e.g. water (which condenses during the reaction) are the by-products. The nylon stockings are really made of nylon, which is a polyamide type synthetic fiber. When this chain is formed, the amino groups react with the carboxyl groups during water exit, so it is a **polymerization (polyaddition) / polycondensation** plastic. The "nylon bag", on the other hand, is made of polyethylene. Write the equation for the polymerization of ethene.

The material of the "nylon bag" is thus a **polymerization (polyaddition) / polycondensation** plastic.

The Hungarian name of the retro vinyl record (“bakelite” record) is also based on a mistake. This is because nothing can be pressed into the **thermosetting** vinyl record (so are not the grooves that can be followed by the needle of the turntable). Therefore, **thermoplastics** are used for this purpose, which are really similar in appearance to the often black bakelite. The difference between these two groups of plastics is that in **thermosetting plastics / thermoplastics** there are only relatively weak secondary bonds between long, chain-like (one-dimensional) molecules that break easily at higher temperatures. In **thermosetting plastics / thermoplastics**, on the other hand, a crosslinked (three-dimensional) structure is held together by covalent bonds, and crosslinking continues due to further thermal action. One way to **recycle** plastic waste is to break it down into smaller organic molecules that can be used for new purposes (**pyrolysis**). However, unfortunately, even today, a lot of plastic is burned. This will inevitably produce carbon dioxide that has greenhouse effect and water, but for some plastics, other harmful products may be released into the air if they are not absorbed. For example, the **burning** of polyvinyl chloride (PVC) produces hydrogen chloride, which causes acid rain. Write a suggestion on how to remove hydrogen chloride chemically from flue (waste) gases.

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**1. Kísérlet:** A tálcátokon található két minta közül az egyik PVC, a másik polietilén. Fogjátok meg az 1. mintát az egyik csipesszel és tartsátok a homoktálba tett borszesz- vagy Bunsen-égő lángjába! (Vigyázzatok, hogy az esetleg megolvadó műanyag a homokra csöppenjen!) Közben a másik csipesszel tartsatok az égő műanyag fölé egy desztillált vízzel megnedvesített univerzális indikátorpapírt. Ismételjétek meg ezt a műveletet a 2. mintával!

**Tapasztalatok:**

1. minta: Magasabb hőmérsékleten **lágyult/keményedett**. A megnedvesített indikátorpapír ……………………. színű.

2. minta: Magasabb hőmérsékleten **lágyult/keményedett**. A megnedvesített indikátorpapír ……………………. színű.

**Magyarázat:**1. minta: A műanyagban **egydimenziós/háromdimenziós** molekulák vannak. Az égésekor erősen savas anyag **keletkezett/nem keletkezett**. 2. minta: A műanyagban **egydimenziós/háromdimenziós** molekulák vannak. Az égésekor erősen savas anyag **keletkezett/nem keletkezett**.

**Következtetés:** A …… számú minta anyaga PVC, mert molekulái láncszerűek, és égéstermékeit vízben oldva erős sav (sósav) keletkezik.

Egy túlzottan egyszerűsítő elképzelés szerint a biológiailag (tehát mikroorganizmusok által) lebontható (**biodegradábilis**) műanyagok jók, a többiek rosszak. A környezetbe kerülő, és akár évezredekig nem lebomló műanyag hulladék szennyező hatása kétségtelen. Az állati és emberi szervezetbe jutó, fölaprózódott műanyagrészecskék hosszú távú hatásai pedig még ismeretlenek. Igaz az is, hogy a politejsav[[1]](#footnote-1) például műtétek során igen alkalmas varrófonálnak, mert a szervezetben kb. 2 év alatt lebomlik. Egyre több területen alkalmazzák a jól komposztálható, kukoricakeményítőből készült műanyag zacskókat is. Azonban a műanyagok többségének egyik legkedvezőbb tulajdonsága éppen a **tartósság**. Ezért sajnos nem lehet mindegyik műanyag biodegradábilis. Ráadásul a használatuk utáni kezelés során is fölmerülnek problémák.

Nem tartoznak a biológiailag lebomló kategóriába[[2]](#footnote-2)a nagy vízmegkötő képességű „**s**zuper**a**dszorbens **p**olimerek” („SAP”) sem.[[3]](#footnote-3) Mégis nélkülözhetetlenné váltak a papírpelenkákban, különböző betétekben és még virágföldbe keverve is a nedvesség megtartására. (Aki nem hiszi, gondoljon arra, milyen kevés kiömlött folyadékot lehet fölitatni pl. egy papírzsebkendővel!) Az interneten elérhető egyik tanulmányban ez olvasható: „*A cellulózból készült vatta 1 grammja átlagosan 12 g vizet képes megkötni, azonban az SAP 1 grammja képes lehet akár*

*1000 g víz adszorbeálására is*.[[4]](#footnote-4) A következő kísérletekben azt vizsgáljuk, hogy **a saját tömegüknek kb. hányszorosát** képesek megkötni a fenti esetekben a folyadékokból a tálcátokon lévő, főként térhálósított nátrium-poliakrilátból készült SAP műanyag szemcsék.

**2. Kísérlet:** Az egyik főzőpohárban 0,10 g tömegű SAP műanyag szemcse van. Öntsétek hozzá a másikban lévő 100 cm3 desztillált vizet és kevergessétek kb. 5 percig. Tegyétek a mérőhengert a tölcsér alá. A keletkezett gélt addig szűrjétek a tölcsérbe helyezett szűrőpapíron, amíg már fél perc alatt nem csöppen újabb folyadékcsepp a mérőhengerbe. (Ez kb. 8-10 percig tart. Ez alatt elolvashatjátok az alábbi, 3. Kísérlettel kapcsolatos feladatot.) Mérjétek meg a mérőhengerrel[[5]](#footnote-5) a lecsöpögött és a főzőpohárban összegyűlt folyadék térfogatát.

**Tapasztalat:** Kb. ……cm3 folyadék csöpögött le a tölcsérről és gyűlt össze az alatta lévő mérőhengerben.

**Magyarázat:** Az SAP kb. ……cm3, azaz kb. ……g desztillált vizet kötött meg. Ez a saját tömegének kb. ……-szorosa. Ez azért lehetséges, mert a gélbe zárt nátriumionok nagy mennyiségű vizet tudnak megkötni a hidrátburkukban.

**3. Kísérlet:** Érdekes kérdés az is, hogy a szuperadszorbensek vajon desztillált vízből vagy vizes oldatokból (pl. vizelet, vér, öntözővíz) tudnak-e többet megkötni. Ha az oldott anyagokat egyszerűen konyhasóval (NaCl) helyettesítjük, akkor ezt is megvizsgálhatjuk. A szűrőpapíron maradt gélhez adjátok hozzá a tálcátokon található (kb. 1 g) konyhasót, és óvatosan keverjétek meg. Jegyezzétek le, mi történt és próbáljatok rá magyarázatot adni.

**Tapasztalat:**…………………………………………………………………………………………………………………………………………………………

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

**Magyarázat:**………………………………………………………………………………………………………………………………………………………..

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

**20. Student sheet:**

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

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

Ezen a feladatlapon úgynevezett „**modellkísérleteket**” végeztetek. Az 1. Kísérletben az univerzális indikátorpapír megnedvesítésekor a **desztillált víz a csapadékot (esőt) modellezte**. A 2. Kísérlet során a SAP által **felszívandó folyadékokat** is egyszerűen **desztillált vízzel modelleztük**. A tölcsérben lévő szűrőpapír **helyettesítette** pl. a pelenkának vagy az intim betétnek azt a külső részét, amelyben a SAP szemcséket elhelyezik. A 3. Kísérletben a megduzzadt SAP szemcsékhez adott **konyhasóval modelleztük** a valóságban megkötendő folyadékokban (vizelet, vér, öntözővíz) lévő **oldott anyagokat**, amelyek a 2. Kísérletben lévő desztillált vízből hiányoztak. **Jobb lett volna a valóságos alkalmazásokat modellező kísérlet**, ha a 2. Kísérletet eleve olyan **konyhasó-oldattal** végeztük volna el, amely a **vízvisszatartás szempontjából a modellezendő folyadékhoz hasonlóan** viselkedik.

**20. Student sheet:**

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

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

**Experiment 2**:

**20. Student sheet:**

(teacher notes)

[Only for type 1 and 2 student sheets.]

**Experiment 2**:

**Observation:**

[Only for type 2 student sheets.]

While filling in this worksheet you applied the **principles and the practice of the scientific investigations**:

[Only for type 3 student sheets.]

**Experiment 2**: There

**Plan of the series of experiments**:

END OF THE 20. STUDENT SHEETS AND TEACHER NOTES

**21. Student sheet:**

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

**21. Student sheet:**

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

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

**21. Student sheet:**

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

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

**Experiment 2**:

**21. Student sheet:**

(teacher notes)

[Only for type 1 and 2 student sheets.]

**Experiment 2**:

**Observation:**

[Only for type 2 student sheets.]

While filling in this worksheet you applied the **principles and the practice of the scientific investigations**:

[Only for type 3 student sheets.]

**Experiment 2**: There

**Plan of the series of experiments**:

END OF THE 21. STUDENT SHEETS AND TEACHER NOTES

**22. Student sheet:**

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

**22. Student sheet:**

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

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

**22. Student sheet:**

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

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

**Experiment 2**:

**22. Student sheet:**

(teacher notes)

[Only for type 1 and 2 student sheets.]

**Experiment 2**:

**Observation:**

[Only for type 2 student sheets.]

While filling in this worksheet you applied the **principles and the practice of the scientific investigations**:

[Only for type 3 student sheets.]

**Experiment 2**: There

**Plan of the series of experiments**:

END OF THE 22. STUDENT SHEETS AND TEACHER NOTES

**23. Student sheet:**

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

**23. Student sheet:**

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

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

**23. Student sheet:**

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

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

**Experiment 2**:

**23. Student sheet:**

(teacher notes)

[Only for type 1 and 2 student sheets.]

**Experiment 2**:

**Observation:**

[Only for type 2 student sheets.]

While filling in this worksheet you applied the **principles and the practice of the scientific investigations**:

[Only for type 3 student sheets.]

**Experiment 2**: There

**Plan of the series of experiments**:

END OF THE 23. STUDENT SHEETS AND TEACHER NOTES

**24. Student sheet:**

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

**24. Student sheet:**

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

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

**24. Student sheet:**

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

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

**Experiment 2**:

**24. Student sheet:**

(teacher notes)

[Only for type 1 and 2 student sheets.]

**Experiment 2**:

**Observation:**

[Only for type 2 student sheets.]

While filling in this worksheet you applied the **principles and the practice of the scientific investigations**:

[Only for type 3 student sheets.]

**Experiment 2**: There

**Plan of the series of experiments**:

END OF THE 24. STUDENT SHEETS AND TEACHER NOTES

1. <https://hu.wikipedia.org/wiki/Politejsav> [↑](#footnote-ref-1)
2. <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=2ahUKEwjb9L3B26TkAhWIb1AKHSKtBBcQFjAAegQIAxAC&url=http%3A%2F%2Fwww.inc.bme.hu%2Fhu%2Fsubjects%2Fbiokomp%2Feload4.ppt&usg=AOvVaw1dGLQ04U82TwW86VXRYZWU> [↑](#footnote-ref-2)
3. <http://www.ttk.mta.hu/aki/wp-content/uploads/sites/2/2018/06/Polimerek.pdf> [↑](#footnote-ref-3)
4. <https://quattroplast.hu/muanyagipariszemle/2006/02/szuperabszorbens-polimerek-sap-01.pdf> (Az idézett szövegben „abszorpció” szerepel, amelyet „adszorpció”-ra javítottunk, az „egy grammja” kifejezést pedig „1 grammja”-ra.) [↑](#footnote-ref-4)
5. Ha nem áll rendelkezésre mérőhenger, helyette olyan főzőpohár is használható, amelynek a falán van beosztás, mert akkor a megkötött víz térfogata annak alapján is megbecsülhető. [↑](#footnote-ref-5)