**WORKSHEETS AND TEACHER’S NOTES OF THE FOURTH SCHOOL YEAR (2024/2025.)**

It is important to note that the worksheets 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 worksheet 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:

[Természettudományos Oktatásmódszertani Centrum](https://ttomc.elte.hu/publications/92)

[Kutatásalapú kémiatanítás és rendszerszemléletű gondolkodás](https://kemiaszakmodszertan.ttk.elte.hu/content/kutatasalapu-kemiatanitas-es-rendszerszemleletu-gondolkodas.t.48195?m=10580)

Student sheet 19: **19. feladatlap: Latte macchiato és más heterogén rendszerek**

Student sheet 20: **20. feladatlap: Érdemes-e tiszta szesszel flambírozni?**

Student sheet 21: **21. feladatlap: A zéró kóla édes titka**

Student sheet 22: **22. feladatlap: Mennyi a C-vitamin a narancslében?**

Student sheet 23: **23. feladatlap: Egy 4000 éves sikertörténet – az aszpirin**

Student sheet 24: **24. feladatlap: Főtt tojásból kiscsirke?**

**Student sheet 19: Latte macchiato and other heterogeneous systems**

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

Latte macchiato is a coffee drink in which warm milk, hot espresso coffee, and milk foam form three spectacular layers. However, if we start stirring with a spoon, the layers disappear and mix together, because both milk and coffee are aqueous solutions, i.e., they contain solvents of the same polarity. If we layer solvents with different polarities, for example, adding apolar benzene, carbon tetrachloride, or dichloromethane to polar water, the solvents with different polarities will separate from each other. The heterogeneous system formed in this way remains intact even after shaking, with the liquids separating into apolar and polar phases and arranging themselves in order of decreasing density from bottom to top.

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

If we pour gasoline and then water into a test tube, the water will settle at the **bottom/top** of the test tube because its density is **lower/higher** than that of gasoline. Dual-solubility (amphipathic, amphipolar) substances, which have both polar and apolar parts in their molecules, can dissolve in solvents of both polarities. One such substance is ethanol, commonly known as alcohol. If a water-oil heterogeneous system also contains a dual-solubility substance, an emulsion may form when the apolar-polar heterogeneous system is mixed (droplets of one polarity liquid dispersed in the other polarity liquid).

**You will conduct a series of experiments to determine which of the following two options is in the test tube, which contains a colorless liquid in the lower phase and a purple liquid in the upper phase. The options are:**

|  |
| --- |
| Option 1: water and a solution of iodine in gasoline |
| Option 2: a solution of potassium permanganate in water (aqueous solution KMnO4) and dichloromethane |

MATERIALS AND EQUIPMENT:

A two-phase system in a test tube sealed with a stopper, hexane, ethanol, 2 Pasteur pipettes

The densities of the liquids: water 1.00 g/cm3, gasoline 0.72-0.78 g/cm3, dichloromethane 1.33 g/cm3, ethanol 0.79 g/cm3, hexane 0.66 g/cm3. (The solution is dilute, so its density is approximately the same as that of the solvent.)

|  |  |
| --- | --- |
| **Experiment I.**  Add hexane to the test tube and shake. | **Experiment II.**  Add a small amount of ethanol to the resulting mixture and shake. |

THE STEPS OF THE EXPERIMENTS:

(1) Using a dropper (Pasteur pipette) or pouring from a bottle/test tube, add approx. 2 cm3 of hexane to the two-phase system. Observe the number and color of the phases.

(2) Shake the test tube sealed with a rubber stopper. Observe the number and color of the phases.

(3) Then add approx. 2 cm3 of ethanol to the resulting system. Observe the number and color of the phases.

(4) Shake the test tube sealed with a rubber stopper. Observe the number and color of the phases.

**After completing the experiments, write down your observations and explanations. Draw conclusions as well.**

1. OBSERVATIONS:

Hexane increased the volume of the …………..………….……. phase, and after shaking …………..……….…………. Ethanol

initially increased the volume of the ……………………….…. phase, while the color of the …………………………..…. phase

changed to …………………………………... After shaking, the volume of …….………………………………. phase increased, but

the …………………………….…. increased to a greater extent. The color of the upper phase was ………………………….…..,

and that of the lower phase was ………………………………….

2. EXPLANATION: Particles of materials with similar structures easily mix with each other. Hexane is **apolar/polar**. Ethanol is amphipolar, which forms a **brown/purple** solution with iodine due to its oxygen content. Based on this, the upper phase of the unknown two-phase system was **apolar/polar dichloromethane/aqueous solution of potassium permanganate/solution of iodine in gasoline/water.**

3. CONCLUSION: The test tube contained **water and a solution of iodine in gasoline/an aqueous solution of potassium permanganate (KMnO4), and dichloromethane.**

4. LET'S THINK!

The world's demand for crude oil is constantly growing, so significant quantities must be extracted using offshore drilling rigs and transported by tanker. This has already caused numerous disasters at sea.

When gasoline or crude oil reaches the surface of the water, it spreads out due to its apolar nature and low density. Thus, even a small amount of crude oil can spread over a very large area and cause a disaster.

Consuming or inhaling hydrocarbons causes headaches, nausea, vomiting, and death due to accumulation in the body. The feathers of water birds stick together, and oil pollution hinders the animals' ability to feed, breathe, and reproduce, killing them. This can destroy the habitats of humans and animals, causing a serious ecological disaster that may take decades to recover from.

The following methods are used to prevent the spread of oil pollution and to remove it.

a) Think about which ones can be implemented quickly and used in the first phase of defence and restoration, and which ones are only effective in the longer term. Write your answers in the first empty column.

b) We have listed seven additional difficulties and sources of danger. Select which difficulty corresponds to which defence or restoration method and write its number in the appropriate column.

|  |  |  |
| --- | --- | --- |
| *Method* | *Speed of effect* | *Hazards, difficulties* |
| Enclosing the oil slick with a floating cordon. |  |  |
| Skimming and pumping off the thin layer of crude oil floating on the surface of the water. |  |  |
| Replacing the contaminated soil on the shore. |  |  |
| Sprinkling a surfactant (soap-like) substance on the oil slick to form an emulsion of water and crude oil with small droplets of crude oil, which eventually break down. |  |  |
| Igniting and burning the oil slicks. |  |  |
| Adding substances to the oil slick that selectively bind the oil. |  |  |
| Breaking down the oil with the help of enzymes and bacteria. |  |  |

1. Crude oil can enter the food chain by adhering to the surface of the particles that bind it, although the crude oil can be extracted by collecting the particles.

2. The product of decomposition is non-toxic, but the process is extremely time-consuming.

3. Smoke and soot are produced, and the toxic fumes destroy wildlife.

4. The material used is also harmful to wildlife.

5. Strong winds, storms, and tides hinder its effectiveness.

6. The use of heavy machinery can damage wildlife.

7. Solid waste can clog the equipment used for pumping.

**Teacher notes for Student sheet 19. Latte macchiato and other heterogeneous systems**

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

Teachers are kindly asked to encourage their students to do experiments by highlighting the importance of experimentation in science and praising them when they think correctly.

Latte macchiato is a coffee drink in which warm milk, hot espresso coffee, and milk foam form three spectacular layers. However, if we start stirring with a spoon, the layers disappear and mix together, because both milk and coffee are aqueous solutions, i.e., they contain solvents of the same polarity. If we layer solvents with different polarities, for example, adding apolar benzene, carbon tetrachloride, or dichloromethane to polar water, the solvents with different polarities will separate from each other. The heterogeneous system formed in this way remains intact even after shaking, with the liquids separating into apolar and polar phases and arranging themselves in order of decreasing density from bottom to top.

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

If we pour gasoline and then water into a test tube, the water will settle at the **bottom/top** of the test tube because its density is **lower/higher** than that of gasoline. Dual-solubility (amphipathic, amphipolar) substances, which have both polar and apolar parts in their molecules, can dissolve in solvents of both polarities. One such substance is ethanol, commonly known as alcohol. If a water-oil heterogeneous system also contains a dual-solubility substance, an emulsion may form when the apolar-polar heterogeneous system is mixed (droplets of one polarity liquid dispersed in the other polarity liquid).

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| --- |
| Option 1: water and a solution of iodine in gasoline |
| Option 2: a solution of potassium permanganate in water (aqueous solution KMnO4) and dichloromethane |

MATERIALS AND EQUIPMENT:

A two-phase system in a test tube sealed with a stopper, hexane, ethanol, 2 Pasteur pipettes

The densities of the liquids: water 1.00 g/cm3, gasoline 0.72-0.78 g/cm3, dichloromethane 1.33 g/cm3, ethanol 0.79 g/cm3, hexane 0.66 g/cm3. (The solution is dilute, so its density is approximately the same as that of the solvent.)

|  |  |
| --- | --- |
| **Experiment I.**  Add hexane to the test tube and shake. | **Experiment II.**  Add a small amount of ethanol to the resulting mixture and shake. |

THE STEPS OF THE EXPERIMENTS:

(1) Using a dropper (Pasteur pipette) or pouring from a bottle/test tube, add approx. 2 cm3 of hexane to the two-phase system. Observe the number and color of the phases.

(2) Shake the test tube sealed with a rubber stopper. Observe the number and color of the phases.

(3) Then add approx. 2 cm3 of ethanol to the resulting system. Observe the number and color of the phases.

(4) Shake the test tube sealed with a rubber stopper. Observe the number and color of the phases.

**After completing the experiments, write down your observations and explanations. Draw conclusions as well.**

1. OBSERVATIONS:

Hexane increased the volume of the upper (purple) phase, and after shaking this did not change. Ethanol initially increased the volume of the upper phase, while the color of the upper phase changed to (partially) yellowish brown. After shaking, the volume of both phases increased, but the lower increased to a greater extent. The color of the upper phase was purple, and that of the lower phase was pale yellow.

Note: Adding a large amount of ethanol can result in a single brown phase, but this requires approximately ten times the total volume of the two-phase system in ethanol.

2. EXPLANATION: Particles of materials with similar structures easily mix with each other. Hexane is **apolar/polar**. Ethanol is amphipolar, which forms a **brown/purple** solution with iodine due to its oxygen content. Based on this, the upper phase of the unknown two-phase system was **apolar/polar dichloromethane/aqueous solution of potassium permanganate/solution of iodine in gasoline/water.**

3. CONCLUSION: The test tube contained **water and a solution of iodine in gasoline/an aqueous solution of potassium permanganate (KMnO4), and dichloromethane.**

4. LET'S THINK!

The world's demand for crude oil is constantly growing, so significant quantities must be extracted using offshore drilling rigs and transported by tanker. This has already caused numerous disasters at sea.

When gasoline or crude oil reaches the surface of the water, it spreads out due to its apolar nature and low density. Thus, even a small amount of crude oil can spread over a very large area and cause a disaster.

Consuming or inhaling hydrocarbons causes headaches, nausea, vomiting, and death due to accumulation in the body. The feathers of water birds stick together, and oil pollution hinders the animals' ability to feed, breathe, and reproduce, killing them. This can destroy the habitats of humans and animals, causing a serious ecological disaster that may take decades to recover from.

The following methods are used to prevent the spread of oil pollution and to remove it.

a) Think about which ones can be implemented quickly and used in the first phase of defence and restoration, and which ones are only effective in the longer term. Write your answers in the first empty column.

b) We have listed seven additional difficulties and sources of danger. Select which difficulty corresponds to which defence or restoration method and write its number in the appropriate column.

|  |  |  |
| --- | --- | --- |
| *Method* | *Speed of effect* | *Hazards, difficulties* |
| Enclosing the oil slick with a floating cordon. | fast | 5. |
| Skimming and pumping off the thin layer of crude oil floating on the surface of the water. | fast | 7. |
| Replacing the contaminated soil on the shore. | slow | 6. |
| Sprinkling a surfactant (soap-like) substance on the oil slick to form an emulsion of water and crude oil with small droplets of crude oil, which eventually break down. | medium - slow | 4. |
| Igniting and burning the oil slicks. | fast | 3. |
| Adding substances to the oil slick that selectively bind the oil. | medium | 1. |
| Breaking down the oil with the help of enzymes and bacteria. | slow | 2. |

1. Crude oil can enter the food chain by adhering to the surface of the particles that bind it, although the crude oil can be extracted by collecting the particles.

2. The product of decomposition is non-toxic, but the process is extremely time-consuming.

3. Smoke and soot are produced, and the toxic fumes destroy wildlife.

4. The material used is also harmful to wildlife.

5. Strong winds, storms, and tides hinder its effectiveness.

6. The use of heavy machinery can damage wildlife.

7. Solid waste can clog the equipment used for pumping.

**Student sheet 19. Latte macchiato and other heterogeneous systems**

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

Latte macchiato is a coffee drink in which warm milk, hot espresso coffee, and milk foam form three spectacular layers. However, if we start stirring with a spoon, the layers disappear and mix together, because both milk and coffee are aqueous solutions, i.e., they contain solvents of the same polarity. If we layer solvents with different polarities, for example, adding apolar benzene, carbon tetrachloride, or dichloromethane to polar water, the solvents with different polarities will separate from each other. The heterogeneous system formed in this way remains intact even after shaking, with the liquids separating into apolar and polar phases and arranging themselves in order of decreasing density from bottom to top.

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

If we pour gasoline and then water into a test tube, the water will settle at the **bottom/top** of the test tube because its density is **lower/higher** than that of gasoline. Dual-solubility (amphipathic, amphipolar) substances, which have both polar and apolar parts in their molecules, can dissolve in solvents of both polarities. One such substance is ethanol, commonly known as alcohol. If a water-oil heterogeneous system also contains a dual-solubility substance, an emulsion may form when the apolar-polar heterogeneous system is mixed (droplets of one polarity liquid dispersed in the other polarity liquid).

**You will conduct a series of experiments to determine which of the following two options is in the test tube, which contains a colorless liquid in the lower phase and a purple liquid in the upper phase. The options are:**

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| --- |
| Option 1: water and a solution of iodine in gasoline |
| Option 2: a solution of potassium permanganate in water (aqueous solution KMnO4) and dichloromethane |

MATERIALS AND EQUIPMENT:

A two-phase system in a test tube sealed with a stopper, hexane, ethanol, 2 Pasteur pipettes

The densities of the liquids: water 1.00 g/cm3, gasoline 0.72-0.78 g/cm3, dichloromethane 1.33 g/cm3, ethanol 0.79 g/cm3, hexane 0.66 g/cm3. (The solution is dilute, so its density is approximately the same as that of the solvent.)

|  |  |
| --- | --- |
| **Experiment I.**  Add hexane to the test tube and shake. | **Experiment II.**  Add a small amount of ethanol to the resulting mixture and shake. |

THE STEPS OF THE EXPERIMENTS:

(1) Using a dropper (Pasteur pipette) or pouring from a bottle/test tube, add approx. 2 cm3 of hexane to the two-phase system. Observe the number and color of the phases.

(2) Shake the test tube sealed with a rubber stopper. Observe the number and color of the phases.

(3) Then add approx. 2 cm3 of ethanol to the resulting system. Observe the number and color of the phases.

(4) Shake the test tube sealed with a rubber stopper. Observe the number and color of the phases.

**After completing the experiments, write down your observations and explanations. Draw conclusions as well.**

1. OBSERVATIONS:

Hexane increased the volume of the …………..………….……. phase, and after shaking …………..……….…………. Ethanol

initially increased the volume of the ……………………….…. phase, while the color of the …………………………..…. phase

changed to …………………………………... After shaking, the volume of …….………………………………. phase increased, but

the …………………………….…. increased to a greater extent. The color of the upper phase was ………………………….…..,

and that of the lower phase was ………………………………….

2. EXPLANATION: Particles of materials with similar structures easily mix with each other. Hexane is **apolar/polar**. Ethanol is amphipolar, which forms a **brown/purple** solution with iodine due to its oxygen content. Based on this, the upper phase of the unknown two-phase system was **apolar/polar dichloromethane/aqueous solution of potassium permanganate/solution of iodine in gasoline/water.**

3. CONCLUSION: The test tube contained **water and a solution of iodine in gasoline/an aqueous solution of potassium permanganate (KMnO4), and dichloromethane.**

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

4. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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

5. WHAT WAS THE DEPENDENT VARIABLE WHOSE CHANGE DEPENDED ON THE INDEPENDENT VARIABLE?

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

6. HOW COULD YOU TEST THIS DEPENDENT VARIABLE?

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

7. THESE WERE THE ASSUMPTIONS (HYPOTHESISES):

Option 1: If water and a solution of iodine in gasoline are in the test tube, then a little

1. …………………. is added, …………………..……………………………..……………..…………………..…………………..………………
2. …………………. is added, …………………..……………………………..……………..…………………..…………………..………………

Option 2: If a solution of potassium permanganate in water (aqueous solution KMnO4) and dichloromethane are in the test tube, then a little

1. …………………. is added, …………………..……………………………..……………..…………………..…………………..………………
2. …………………. is added, …………………..……………………………..……………..…………………..…………………..………………

8. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with a x sign!

☐ The volume of the added liquid. ☐ The intensity of shaking. ☐ The temperature.

☐ The pipette with that the liquid was added.

9. LET'S THINK!

The world's demand for crude oil is constantly growing, so significant quantities must be extracted using offshore drilling rigs and transported by tanker. This has already caused numerous disasters at sea.

When gasoline or crude oil reaches the surface of the water, it spreads out due to its apolar nature and low density. Thus, even a small amount of crude oil can spread over a very large area and cause a disaster.

Consuming or inhaling hydrocarbons causes headaches, nausea, vomiting, and death due to accumulation in the body. The feathers of water birds stick together, and oil pollution hinders the animals' ability to feed, breathe, and reproduce, killing them. This can destroy the habitats of humans and animals, causing a serious ecological disaster that may take decades to recover from.

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|  |  |  |
| --- | --- | --- |
| *Method* | *Speed of effect* | *Hazards, difficulties* |
| Enclosing the oil slick with a floating cordon. |  |  |
| Skimming and pumping off the thin layer of crude oil floating on the surface of the water. |  |  |
| Replacing the contaminated soil on the shore. |  |  |
| Sprinkling a surfactant (soap-like) substance on the oil slick to form an emulsion of water and crude oil with small droplets of crude oil, which eventually break down. |  |  |
| Igniting and burning the oil slicks. |  |  |
| Adding substances to the oil slick that selectively bind the oil. |  |  |
| Breaking down the oil with the help of enzymes and bacteria. |  |  |

1. Crude oil can enter the food chain by adhering to the surface of the particles that bind it, although the crude oil can be extracted by collecting the particles.

2. The product of decomposition is non-toxic, but the process is extremely time-consuming.

3. Smoke and soot are produced, and the toxic fumes destroy wildlife.

4. The material used is also harmful to wildlife.

5. Strong winds, storms, and tides hinder its effectiveness.

6. The use of heavy machinery can damage wildlife.

7. Solid waste can clog the equipment used for pumping.

**Teacher notes for Student sheet 19. Latte macchiato and other heterogeneous systems**

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

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

Latte macchiato is a coffee drink in which warm milk, hot espresso coffee, and milk foam form three spectacular layers. However, if we start stirring with a spoon, the layers disappear and mix together, because both milk and coffee are aqueous solutions, i.e., they contain solvents of the same polarity. If we layer solvents with different polarities, for example, adding apolar benzene, carbon tetrachloride, or dichloromethane to polar water, the solvents with different polarities will separate from each other. The heterogeneous system formed in this way remains intact even after shaking, with the liquids separating into apolar and polar phases and arranging themselves in order of decreasing density from bottom to top.

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

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MATERIALS AND EQUIPMENT:

A two-phase system in a test tube sealed with a stopper, hexane, ethanol, 2 Pasteur pipettes

The densities of the liquids: water 1.00 g/cm3, gasoline 0.72-0.78 g/cm3, dichloromethane 1.33 g/cm3, ethanol 0.79 g/cm3, hexane 0.66 g/cm3. (The solution is dilute, so its density is approximately the same as that of the solvent.)

|  |  |
| --- | --- |
| **Experiment I.**  Add hexane to the test tube and shake. | **Experiment II.**  Add a small amount of ethanol to the resulting mixture and shake. |

THE STEPS OF THE EXPERIMENTS:

(1) Using a dropper (Pasteur pipette) or pouring from a bottle/test tube, add approx. 2 cm3 of hexane to the two-phase system. Observe the number and color of the phases.

(2) Shake the test tube sealed with a rubber stopper. Observe the number and color of the phases.

(3) Then add approx. 2 cm3 of ethanol to the resulting system. Observe the number and color of the phases.

(4) Shake the test tube sealed with a rubber stopper. Observe the number and color of the phases.

**After completing the experiments, write down your observations and explanations. Draw conclusions as well.**

1. OBSERVATIONS:

Hexane increased the volume of the upper (purple) phase, and after shaking this did not change. Ethanol initially increased the volume of the upper phase, while the color of the upper phase changed to (partially) yellowish brown. After shaking, the volume of both phases increased, but the lower increased to a greater extent. The color of the upper phase was purple, and that of the lower phase was pale yellow.

Note: Adding a large amount of ethanol can result in a single brown phase, but this requires approximately ten times the total volume of the two-phase system in ethanol.

2. EXPLANATION: Particles of materials with similar structures easily mix with each other. Hexane is **apolar/polar**. Ethanol is amphipolar, which forms a **brown/purple** solution with iodine due to its oxygen content. Based on this, the upper phase of the unknown two-phase system was **apolar/polar dichloromethane/aqueous solution of potassium permanganate/solution of iodine in gasoline/water.**

3. CONCLUSION: The test tube contained **water and a solution of iodine in gasoline/an aqueous solution of potassium permanganate (KMnO4), and dichloromethane.**

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

4. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

The quality of the solvent added to the two-phase system.

5. WHAT WAS THE DEPENDENT VARIABLE WHOSE CHANGE DEPENDED ON THE INDEPENDENT VARIABLE?

The similarity or difference between the polarity of the unknown phases and the added solvent.

6. HOW COULD YOU TEST THIS DEPENDENT VARIABLE?

By observing how many phases there were before and after shaking, their volume, and their color.

7. THESE WERE THE ASSUMPTIONS (HYPOTHESISES):

Option 1: If water and a solution of iodine in gasoline are in the test tube, then a little

* 1. hexane is added, only the volume of the upper purple phase increases.
  2. ethanol is added, the color of the upper phase changes to yellowish brown.

Option 2: If a solution of potassium permanganate in water (aqueous solution KMnO4) and dichloromethane are in the test tube, then a little

* + - 1. hexane is added, a third, colorless upper phase is formed.
      2. ethanol is added, the color of the purple phase does not change.

8. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with a x sign!

The volume of the added liquid.  The intensity of shaking.  The temperature.

☐ The pipette with that the liquid was added.

9. LET'S THINK!

The world's demand for crude oil is constantly growing, so significant quantities must be extracted using offshore drilling rigs and transported by tanker. This has already caused numerous disasters at sea.

When gasoline or crude oil reaches the surface of the water, it spreads out due to its apolar nature and low density. Thus, even a small amount of crude oil can spread over a very large area and cause a disaster.

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b) We have listed seven additional difficulties and sources of danger. Select which difficulty corresponds to which defence or restoration method and write its number in the appropriate column.

|  |  |  |
| --- | --- | --- |
| *Method* | *Speed of effect* | *Hazards, difficulties* |
| Enclosing the oil slick with a floating cordon. | fast | 5. |
| Skimming and pumping off the thin layer of crude oil floating on the surface of the water. | fast | 7. |
| Replacing the contaminated soil on the shore. | slow | 6. |
| Sprinkling a surfactant (soap-like) substance on the oil slick to form an emulsion of water and crude oil with small droplets of crude oil, which eventually break down. | medium - slow | 4. |
| Igniting and burning the oil slicks. | fast | 3. |
| Adding substances to the oil slick that selectively bind the oil. | medium | 1. |
| Breaking down the oil with the help of enzymes and bacteria. | slow | 2. |

1. Crude oil can enter the food chain by adhering to the surface of the particles that bind it, although the crude oil can be extracted by collecting the particles.

2. The product of decomposition is non-toxic, but the process is extremely time-consuming.

3. Smoke and soot are produced, and the toxic fumes destroy wildlife.

4. The material used is also harmful to wildlife.

5. Strong winds, storms, and tides hinder its effectiveness.

6. The use of heavy machinery can damage wildlife.

7. Solid waste can clog the equipment used for pumping.

**Student sheet 19: Latte macchiato and other heterogeneous systems**

(type 3: experimental design following a scheme version for Group 3 students)

Latte macchiato is a coffee drink in which warm milk, hot espresso coffee, and milk foam form three spectacular layers. However, if we start stirring with a spoon, the layers disappear and mix together, because both milk and coffee are aqueous solutions, i.e., they contain solvents of the same polarity. If we layer solvents with different polarities, for example, adding apolar benzene, carbon tetrachloride, or dichloromethane to polar water, the solvents with different polarities will separate from each other. The heterogeneous system formed in this way remains intact even after shaking, with the liquids separating into apolar and polar phases and arranging themselves in order of decreasing density from bottom to top.

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

If we pour gasoline and then water into a test tube, the water will settle at the **bottom/top** of the test tube because its density is **lower/higher** than that of gasoline. Dual-solubility (amphipathic, amphipolar) substances, which have both polar and apolar parts in their molecules, can dissolve in solvents of both polarities. One such substance is ethanol, commonly known as alcohol. If a water-oil heterogeneous system also contains a dual-solubility substance, an emulsion may form when the apolar-polar heterogeneous system is mixed (droplets of one polarity liquid dispersed in the other polarity liquid).

**Design an experiment to determine which of the following two options is in the test tube, which contains a colorless liquid in the lower phase and a purple liquid in the upper phase. The options are:**

|  |
| --- |
| Option 1: water and a solution of iodine in gasoline |
| Option 2: a solution of potassium permanganate in water (aqueous solution KMnO4) and dichloromethane |

MATERIALS AND EQUIPMENT:

A two-phase system in a test tube sealed with a stopper, hexane, ethanol, 2 Pasteur pipettes

The densities of the liquids: water 1.00 g/cm3, gasoline 0.72-0.78 g/cm3, dichloromethane 1.33 g/cm3, ethanol 0.79 g/cm3, hexane 0.66 g/cm3. (The solution is dilute, so its density is approximately the same as that of the solvent.)

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

1. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAVE TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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

2. WHAT IS THE DEPENDENT VARIABLE WHOSE CHANGE DEPENDS ON THE INDEPENDENT VARIABLE?

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

3. HOW CAN YOU TEST THIS DEPENDENT VARIABLE?

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

4. THESE ARE THE ASSUMPTIONS (HYPOTHESISES):

Option 1: If water and a solution of iodine in gasoline are in the test tube, then a little

A) …………………. is added, …………………..……………………………..……………..…………………..…………………..………

B) …………………. is added, …………………..……………………………..……………..…………………..…………………..………

Option 2: If a solution of potassium permanganate in water (aqueous solution KMnO4) and dichloromethane are in the test tube, then a little

A) …………………. is added, …………………..……………………………..……………..…………………..…………………..………………….

* + 1. …………………. is added, …………………..……………………………..……………..…………………..…………………..…………….…

5. HOW CAN THE INDEPENDENT VARIABLE CHANGE? Check the results of Experiment 1 with Experiment 2!

|  |  |
| --- | --- |
| Experiment 1  Add ……………. to the test tube and shake. | Experiment 2  Add ………………. to the resulting mixture and shake. |
| number of repetitions in class: | number of repetitions in class: |

6. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with a x sign!

☐ The volume of the added liquid. ☐ The intensity of shaking. ☐ The temperature.

☐ The pipette with that the liquid was added.

7. THE STEPS OF THE EXPERIMENTS:

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

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

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

**After the experiments are done, write down your observations and explanations. Draw your own conclusions too.**

8. OBSERVATION:

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

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

…………………………………………………………………………………………………………………………………………………………………………….9. EXPLANATION: Particles of materials with similar structures easily mix with each other. Hexane is **apolar/polar**. Ethanol is amphipolar, which forms a **brown/purple** solution with iodine due to its oxygen content. Based on this, the upper phase of the unknown two-phase system was **apolar/polar dichloromethane/aqueous solution of potassium permanganate/solution of iodine in gasoline/water.**

10. CONCLUSION: The test tube contained **water and a solution of iodine in gasoline/an aqueous solution of potassium permanganate (KMnO4), and dichloromethane.**

11. LET'S THINK!

The world's demand for crude oil is constantly growing, so significant quantities must be extracted using offshore drilling rigs and transported by tanker. This has already caused numerous disasters at sea.

When gasoline or crude oil reaches the surface of the water, it spreads out due to its apolar nature and low density. Thus, even a small amount of crude oil can spread over a very large area and cause a disaster.

Consuming or inhaling hydrocarbons causes headaches, nausea, vomiting, and death due to accumulation in the body. The feathers of water birds stick together, and oil pollution hinders the animals' ability to feed, breathe, and reproduce, killing them. This can destroy the habitats of humans and animals, causing a serious ecological disaster that may take decades to recover from.

The following methods are used to prevent the spread of oil pollution and to remove it.

a) Think about which ones can be implemented quickly and used in the first phase of defence and restoration, and which ones are only effective in the longer term. Write your answers in the first empty column.

b) We have listed seven additional difficulties and sources of danger. Select which difficulty corresponds to which defence or restoration method and write its number in the appropriate column.

|  |  |  |
| --- | --- | --- |
| *Method* | *Speed of effect* | *Hazards, difficulties* |
| Enclosing the oil slick with a floating cordon. |  |  |
| Skimming and pumping off the thin layer of crude oil floating on the surface of the water. |  |  |
| Replacing the contaminated soil on the shore. |  |  |
| Sprinkling a surfactant (soap-like) substance on the oil slick to form an emulsion of water and crude oil with small droplets of crude oil, which eventually break down. |  |  |
| Igniting and burning the oil slicks. |  |  |
| Adding substances to the oil slick that selectively bind the oil. |  |  |
| Breaking down the oil with the help of enzymes and bacteria. |  |  |

1. Crude oil can enter the food chain by adhering to the surface of the particles that bind it, although the crude oil can be extracted by collecting the particles.

2. The product of decomposition is non-toxic, but the process is extremely time-consuming.

3. Smoke and soot are produced, and the toxic fumes destroy wildlife.

4. The material used is also harmful to wildlife.

5. Strong winds, storms, and tides hinder its effectiveness.

6. The use of heavy machinery can damage wildlife.

7. Solid waste can clog the equipment used for pumping.

**Teacher notes for Student sheet 19. Latte macchiato and other heterogeneous systems**

(type 3: experimental design following a scheme version for Group 3 students)

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

Latte macchiato is a coffee drink in which warm milk, hot espresso coffee, and milk foam form three spectacular layers. However, if we start stirring with a spoon, the layers disappear and mix together, because both milk and coffee are aqueous solutions, i.e., they contain solvents of the same polarity. If we layer solvents with different polarities, for example, adding apolar benzene, carbon tetrachloride, or dichloromethane to polar water, the solvents with different polarities will separate from each other. The heterogeneous system formed in this way remains intact even after shaking, with the liquids separating into apolar and polar phases and arranging themselves in order of decreasing density from bottom to top.

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

If we pour gasoline and then water into a test tube, the water will settle at the **bottom/top** of the test tube because its density is **lower/higher** than that of gasoline. Dual-solubility (amphipathic, amphipolar) substances, which have both polar and apolar parts in their molecules, can dissolve in solvents of both polarities. One such substance is ethanol, commonly known as alcohol. If a water-oil heterogeneous system also contains a dual-solubility substance, an emulsion may form when the apolar-polar heterogeneous system is mixed (droplets of one polarity liquid dispersed in the other polarity liquid).

**Design an experiment to determine which of the following two options is in the test tube, which contains a colorless liquid in the lower phase and a purple liquid in the upper phase. The options are:**

|  |
| --- |
| Option 1: water and a solution of iodine in gasoline |
| Option 2: a solution of potassium permanganate in water (aqueous solution KMnO4) and dichloromethane |

MATERIALS AND EQUIPMENT:

A two-phase system in a test tube sealed with a stopper, hexane, ethanol, 2 Pasteur pipettes

The densities of the liquids: water 1.00 g/cm3, gasoline 0.72-0.78 g/cm3, dichloromethane 1.33 g/cm3, ethanol 0.79 g/cm3, hexane 0.66 g/cm3. (The solution is dilute, so its density is approximately the same as that of the solvent.)

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

1. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAVE TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

The quality of the solvent added to the two-phase system.

2. WHAT IS THE DEPENDENT VARIABLE WHOSE CHANGE DEPENDS ON THE INDEPENDENT VARIABLE?

The similarity or difference between the polarity of the unknown phases and the added solvent.

3. HOW CAN YOU TEST THIS DEPENDENT VARIABLE?

By observing how many phases there were before and after shaking, their volume, and their color.

4. THESE ARE THE ASSUMPTIONS (HYPOTHESISES):

Option 1: If water and a solution of iodine in gasoline are in the test tube, then a little

A) hexane is added, only the volume of the upper purple phase increases.

B) ethanol is added, the color of the upper phase changes to yellowish brown.

Option 2: If a solution of potassium permanganate in water (aqueous solution KMnO4) and dichloromethane are in the test tube, then a little

A) hexane is added, a third, colorless upper phase is formed.

B) ethanol is added, the color of the purple phase does not change.

5. HOW CAN THE INDEPENDENT VARIABLE CHANGE? Check the results of Experiment 1 with Experiment 2!

|  |  |
| --- | --- |
| Experiment 1  Add hexane to the test tube and shake. | Experiment 2  Add ethanol to the resulting mixture and shake. |
| number of repetitions in class: | number of repetitions in class: |

6. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with a x sign!

The volume of the added liquid.  The intensity of shaking.  The temperature.

☐ The pipette with that the liquid was added.

7. THE STEPS OF THE EXPERIMENTS:

(1) Add a small amount of hexane to the two-phase system in the test tube and observe the number and volume of phases before and after shaking.

(2) Repeat the previous step with ethanol.

**After the experiments are done, write down your observations and explanations. Draw your own conclusions too.**

8. OBSERVATION:

Hexane always increased the volume of the upper (purple) phase, and this did not change even after shaking. A small amount of ethanol initially increased the volume of the upper phase, while the color of the upper phase changed (partially) to yellowish brown. After shaking, the volume of both phases increased, but the lower phase increased to a greater extent. The upper phase is purple in color, while the lower phase is pale yellow. Adding a large amount of ethanol could result in a single brown phase.

9. EXPLANATION: Particles of materials with similar structures easily mix with each other. Hexane is **apolar/polar**. Ethanol is amphipolar, which forms a **brown/purple** solution with iodine due to its oxygen content. Based on this, the upper phase of the unknown two-phase system was **apolar/polar dichloromethane/aqueous solution of potassium permanganate/solution of iodine in gasoline/water.**

10. CONCLUSION: The test tube contained **water and a solution of iodine in gasoline/an aqueous solution of potassium permanganate (KMnO4), and dichloromethane.**

11. LET'S THINK!

The world's demand for crude oil is constantly growing, so significant quantities must be extracted using offshore drilling rigs and transported by tanker. This has already caused numerous disasters at sea.

When gasoline or crude oil reaches the surface of the water, it spreads out due to its apolar nature and low density. Thus, even a small amount of crude oil can spread over a very large area and cause a disaster.

Consuming or inhaling hydrocarbons causes headaches, nausea, vomiting, and death due to accumulation in the body. The feathers of water birds stick together, and oil pollution hinders the animals' ability to feed, breathe, and reproduce, killing them. This can destroy the habitats of humans and animals, causing a serious ecological disaster that may take decades to recover from.

The following methods are used to prevent the spread of oil pollution and to remove it.

a) Think about which ones can be implemented quickly and used in the first phase of defence and restoration, and which ones are only effective in the longer term. Write your answers in the first empty column.

b) We have listed seven additional difficulties and sources of danger. Select which difficulty corresponds to which defence or restoration method and write its number in the appropriate column.

|  |  |  |
| --- | --- | --- |
| *Method* | *Speed of effect* | *Hazards, difficulties* |
| Enclosing the oil slick with a floating cordon. | fast | 5. |
| Skimming and pumping off the thin layer of crude oil floating on the surface of the water. | fast | 7. |
| Replacing the contaminated soil on the shore. | slow | 6. |
| Sprinkling a surfactant (soap-like) substance on the oil slick to form an emulsion of water and crude oil with small droplets of crude oil, which eventually break down. | medium - slow | 4. |
| Igniting and burning the oil slicks. | fast | 3. |
| Adding substances to the oil slick that selectively bind the oil. | medium | 1. |
| Breaking down the oil with the help of enzymes and bacteria. | slow | 2. |

1. Crude oil can enter the food chain by adhering to the surface of the particles that bind it, although the crude oil can be extracted by collecting the particles.

2. The product of decomposition is non-toxic, but the process is extremely time-consuming.

3. Smoke and soot are produced, and the toxic fumes destroy wildlife.

4. The material used is also harmful to wildlife.

5. Strong winds, storms, and tides hinder its effectiveness.

6. The use of heavy machinery can damage wildlife.

7. Solid waste can clog the equipment used for pumping.

END OF THE 19th STUDENT SHEETS AND TEACHER NOTES

**Student sheet 20: Is it worth flambéing with pure alcohol?**

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

"Flambéing is a roasting process used when cooking meat, serving desserts and spirits, which is done with flaming spirits... Meat is flambéed at the beginning or end of preparation, or during the preparation of the dish, according to the instructions in certain recipes. [...] A reliable method of flambéing is to heat the alcohol in a ladle or tablespoon over a gas flame, then tilt the spoon slightly, light it, and pour it over the food."

"If possible, use 40% alcohol (vodka, rum, cognac, brandy, whiskey, fruit liqueurs...) to pour over the food." But would it be worthwhile for an enthusiastic beginner to use 96% by volume "pure spirit" in the hope of achieving even better results? Or could those who prefer coconut flavour replace the 40% alcohol beverages listed above with Malibu liqueur, which contains approximately 20% by volume alcohol? In this lesson, you will seek answers to these questions.

**When completing the worksheet, underline or frame the correct text or ~~cross out~~ the incorrect text.**

Watch the video at the following link to see how flambéing is done and complete the text:

<https://www.facebook.com/gundel.restaurant/videos/1729088467127088>

What can we observe during the process? The alcoholic beverage ………………………………………………………………………

Meanwhile, the surface of the pancake **burns/does not burn**.

Write down the reaction equation for the complete combustion of ethanol!

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

MATERIALS AND EQUIPMENT: 3 small Petri dishes or beakers, glass rod, tweezers, 3 pieces of paper tissue approx. 2x2 cm, 96% ethanol, tap water in a beaker, 2 10 ml syringes or measuring cylinders, porcelain dish with sand, candle, matches

|  |  |  |
| --- | --- | --- |
| Experiment 1: 96% by volume mixture | Experiment 2: 40% by volume mixture | Experiment 3: 20% by volume mixture |
| 96% alcohol (“pure spirit”), a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. | 4 cm3 of pure spirit diluted to  10 cm3 + a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. | 2 cm3 of pure spirit diluted to  10 cm3 + a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. |

STEPS OF THE EXPERIMENT

1) Dip a piece of paper tissue held with tweezers into the 96% by volume mixture ("pure spirit"), drain it, then try to light it over a bowl of sand.

2) To prepare a mixture of approximately 40% by volume, dilute 4 cm3 of pure spirit with water to 10 cm3 using measuring cylinders or syringes.

3) Dip a piece of paper tissue held with tweezers into the mixture of approximately 40% by volume, then try to ignite it over a bowl of sand.

4) To prepare a mixture of approximately 20% by volume, dilute 2 cm3 of pure spirit with water to 10 cm3 using measuring cylinders or syringes.

5) Dip a piece of paper tissue held with tweezers into the mixture containing approximately 20% by volume, then try to ignite it over a bowl of sand.

1. OBSERVATIONS:

Experiment 1: ………………………………………………………………………………………………………………………………………………………

Experiment 2: ………………………………………………………………………………………………………………………………………………………

Experiment 3: ………………………………………………………………………………………………………………………………………………………

2. Explanation: In alcoholic beverages (alcohol-water mixtures), **alcohol/water** is the combustible component. Combustion is a **heat-generating/heat-absorbing physical/chemical process**. Combustion is accompanied by the evaporation of the non-combustible component. Evaporation is a **heat-generating/heat-absorbing physical/chemical process**.

Experiment 1: The 96% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 2: The 40% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 3: The 20% mixture **contains/does not contain** enough alcohol to burn, and **contains/does not contain** enough water to absorb the heat.

3. CONCLUSION: The use of 96% pure alcohol **improves/impairs/does not change** the quality of food, **recommended/not recommended** for flambéing. Approximately 20% liqueur **can/cannot be used** for flambéing.

4. LET’S THINK!

Alcohol is a cell poison and alcoholism is a widespread disease. However, rules for civilized alcohol consumption have developed over the course of human civilization, requiring us to strike a delicate balance:

"*We do not need alcohol to sustain our bodies. Although it has a very high energy content—one gram of alcohol contains 7 kcal/g —it does not provide us with any nutrients, so it is actually unnecessary for us. […] Most of us consider ourselves moderate drinkers and are confident that we will not suffer any damage to our health. However, the actual standard is not based on our subjective assessment, but on the physiological limits of our bodies. Professional recommendations are also based on this. [...] The recommended amount is a maximum of 2 standard drinks per day for adult men and a maximum of 1 standard drink per day for adult women – with at least 2 days off per week. During pregnancy and breastfeeding, it is important for mothers to avoid alcohol consumption, as it hinders the development of the foetus/child. A drink containing 10 grams of alcohol is considered one standard unit. The amounts consumed at home or served in restaurants are usually greater than one unit*.”

How many standard alcohol units does someone consume when drinking the following beverages? Fill in the table! (The density of absolute alcohol is 0.789 g/cm3.)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Volume of 1 glass of alcoholic beverage | Ethanol content  (% by volume) | Volume of ethanol  (ml or cm3) | Mass of ethanol (g) | Standard alcohol unit | How many glasses (or deciliters) of alcoholic beverage contain 5 standard units, which is the maximum amount that can be consumed by an adult woman in one week? |
| 1 glass of beer:  2.5 dl | 5.0 |  |  |  |  |
| 1 glass of wine:  1.5 dl | 13 |  |  |  |  |
| 1 glass of brandy:  0.5 dl | 40 |  |  |  |  |

**Teacher notes for Student sheet 20: Is it worth flambéing with pure alcohol?**

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

Teachers are kindly asked to encourage their students to do experiments by highlighting the importance of experimentation in science and praising them when they think correctly.

"Flambéing is a roasting process used when cooking meat, serving desserts and spirits, which is done with flaming spirits... Meat is flambéed at the beginning or end of preparation, or during the preparation of the dish, according to the instructions in certain recipes. [...] A reliable method of flambéing is to heat the alcohol in a ladle or tablespoon over a gas flame, then tilt the spoon slightly, light it, and pour it over the food."

"If possible, use 40% alcohol (vodka, rum, cognac, brandy, whiskey, fruit liqueurs...) to pour over the food." But would it be worthwhile for an enthusiastic beginner to use 96% by volume "pure spirit" in the hope of achieving even better results? Or could those who prefer coconut flavour replace the 40% alcohol beverages listed above with Malibu liqueur, which contains approximately 20% by volume alcohol? In this lesson, you will seek answers to these questions.

**When completing the worksheet, underline or frame the correct text or ~~cross out~~ the incorrect text.**

Watch the video at the following link to see how flambéing is done and complete the text:

<https://www.facebook.com/gundel.restaurant/videos/1729088467127088>

What can we observe during the process? The alcoholic beverage burns with a blue flame.

Meanwhile, the surface of the pancake **burns/does not burn**.

Write down the reaction equation for the complete combustion of ethanol!

C2H5OH + 3 O2 = 2 CO2 + 3 H2O

MATERIALS AND EQUIPMENT: 3 small Petri dishes or beakers, glass rod, tweezers, 3 pieces of paper tissue approx. 2x2 cm, 96% ethanol, tap water in a beaker, 2 10 ml syringes or measuring cylinders, porcelain dish with sand, candle, matches

|  |  |  |
| --- | --- | --- |
| Experiment 1: 96% by volume mixture | Experiment 2: 40% by volume mixture | Experiment 3: 20% by volume mixture |
| 96% alcohol (“pure spirit”), a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. | 4 cm3 of pure spirit diluted to  10 cm3 + a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. | 2 cm3 of pure spirit diluted to  10 cm3 + a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. |

STEPS OF THE EXPERIMENT

1) Dip a piece of paper tissue held with tweezers into the 96% by volume mixture ("pure spirit"), drain it, then try to light it over a bowl of sand.

2) To prepare a mixture of approximately 40% by volume, dilute 4 cm3 of pure spirit with water to 10 cm3 using measuring cylinders or syringes.

3) Dip a piece of paper tissue held with tweezers into the mixture of approximately 40% by volume, then try to ignite it over a bowl of sand.

4) To prepare a mixture of approximately 20% by volume, dilute 2 cm3 of pure spirit with water to 10 cm3 using measuring cylinders or syringes.

5) Dip a piece of paper tissue held with tweezers into the mixture containing approximately 20% by volume, then try to ignite it over a bowl of sand.

1. OBSERVATIONS:

Experiment 1: When the paper tissue is removed from the flame, combustion continues, and then the paper tissue also ignites and burns to ash.

Experiment 2: When the paper tissue is removed from the flame, combustion continues, but the tissue does not ignite.

Experiment 3: When the paper tissue is removed from the flame, no burning is observed.

2. Explanation: In alcoholic beverages (alcohol-water mixtures), **alcohol/water** is the combustible component. Combustion is a **heat-generating/heat-absorbing physical/chemical process**. Combustion is accompanied by the evaporation of the non-combustible component. Evaporation is a **heat-generating/heat-absorbing physical/chemical process**.

Experiment 1: The 96% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 2: The 40% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 3: The 20% mixture **contains/does not contain** enough alcohol to burn, and **contains/does not contain** enough water to absorb the heat.

3. CONCLUSION: The use of 96% pure alcohol **improves/impairs/does not change** the quality of food, **recommended/not recommended** for flambéing. Approximately 20% liqueur **can/cannot be used** for flambéing.

4. LET’S THINK!

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| 1 glass of beer:  2.5 dl | 5.0 | 250 x 0.05=  12.5 | 12.5 x 0.789≈  10 | ≈1 | 5 : 1≈5 glasses  (5 glasses x 2.5 dl/glass≈12.5 dl) |
| 1 glass of wine:  1.5 dl | 13 | 150 x 0.13=  19.5 | 19.5 x 0.789≈  15 | ≈1.5 | 5 : 1.5≈3.3 glasses  (3.3 glasses x 1.5 dl/glass≈5 dl) |
| 1 glass of brandy:  0.5 dl | 40 | 50 x 0.40=  20 | 20 x 0.789≈  16 | ≈1.6 | 5 : 1.6≈3.1 glasses  (3.1 glasses x 0.5 dl/glass≈1.6 dl) |

**Student sheet 20: Is it worth flambéing with pure alcohol?**

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

"Flambéing is a roasting process used when cooking meat, serving desserts and spirits, which is done with flaming spirits... Meat is flambéed at the beginning or end of preparation, or during the preparation of the dish, according to the instructions in certain recipes. [...] A reliable method of flambéing is to heat the alcohol in a ladle or tablespoon over a gas flame, then tilt the spoon slightly, light it, and pour it over the food."

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What can we observe during the process? The alcoholic beverage ………………………………………………………………………

Meanwhile, the surface of the pancake **burns/does not burn**.

Write down the reaction equation for the complete combustion of ethanol!

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

MATERIALS AND EQUIPMENT: 3 small Petri dishes or beakers, glass rod, tweezers, 3 pieces of paper tissue approx. 2x2 cm, 96% ethanol, tap water in a beaker, 2 10 ml syringes or measuring cylinders, porcelain dish with sand, candle, matches

|  |  |  |
| --- | --- | --- |
| Experiment 1: 96% by volume mixture | Experiment 2: 40% by volume mixture | Experiment 3: 20% by volume mixture |
| 96% alcohol (“pure spirit”), a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. | 4 cm3 of pure spirit diluted to  10 cm3 + a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. | 2 cm3 of pure spirit diluted to  10 cm3 + a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. |

STEPS OF THE EXPERIMENT

1) Dip a piece of paper tissue held with tweezers into the 96% by volume mixture ("pure spirit"), drain it, then try to light it over a bowl of sand.

2) To prepare a mixture of approximately 40% by volume, dilute 4 cm3 of pure spirit with water to 10 cm3 using measuring cylinders or syringes.

3) Dip a piece of paper tissue held with tweezers into the mixture of approximately 40% by volume, then try to ignite it over a bowl of sand.

4) To prepare a mixture of approximately 20% by volume, dilute 2 cm3 of pure spirit with water to 10 cm3 using measuring cylinders or syringes.

5) Dip a piece of paper tissue held with tweezers into the mixture containing approximately 20% by volume, then try to ignite it over a bowl of sand.

1. OBSERVATIONS:

Experiment 1: ………………………………………………………………………………………………………………………………………………………

Experiment 2: ………………………………………………………………………………………………………………………………………………………

Experiment 3: ………………………………………………………………………………………………………………………………………………………

2. Explanation: In alcoholic beverages (alcohol-water mixtures), **alcohol/water** is the combustible component. Combustion is a **heat-generating/heat-absorbing physical/chemical process**. Combustion is accompanied by the evaporation of the non-combustible component. Evaporation is a **heat-generating/heat-absorbing physical/chemical process**.

Experiment 1: The 96% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 2: The 40% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 3: The 20% mixture **contains/does not contain** enough alcohol to burn, and **contains/does not contain** enough water to absorb the heat.

3. CONCLUSION: The use of 96% pure alcohol **improves/impairs/does not change** the quality of food, **recommended/not recommended** for flambéing. Approximately 20% liqueur **can/cannot be used** for flambéing.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

4. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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

5. WHAT WAS THE DEPENDENT VARIABLE?

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

6. HOW COULD YOU TEST THIS DEPENDENT VARIABLE?

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

7. WHAT WAS THE ASSUMPTION (HYPOTHESIS): ………………………………………………………………………………………………….

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

8. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X** sign!

☐ The shape of the glass. ☐ The size of the paper tissue.

☐ The volume of the alcoholic mixture. ☐ The quality of the paper tissue.

9. LET’S THINK!

Alcohol is a cell poison and alcoholism is a widespread disease. However, rules for civilized alcohol consumption have developed over the course of human civilization, requiring us to strike a delicate balance:

"*We do not need alcohol to sustain our bodies. Although it has a very high energy content—one gram of alcohol contains 7 kcal/g —it does not provide us with any nutrients, so it is actually unnecessary for us. […] Most of us consider ourselves moderate drinkers and are confident that we will not suffer any damage to our health. However, the actual standard is not based on our subjective assessment, but on the physiological limits of our bodies. Professional recommendations are also based on this. [...] The recommended amount is a maximum of 2 standard drinks per day for adult men and a maximum of 1 standard drink per day for adult women – with at least 2 days off per week. During pregnancy and breastfeeding, it is important for mothers to avoid alcohol consumption, as it hinders the development of the foetus/child. A drink containing 10 grams of alcohol is considered one standard unit. The amounts consumed at home or served in restaurants are usually greater than one unit*.”

How many standard alcohol units does someone consume when drinking the following beverages? Fill in the table! (The density of absolute alcohol is 0.789 g/cm3.)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Volume of 1 glass of alcoholic beverage | Ethanol content  (% by volume) | Volume of ethanol  (ml or cm3) | Mass of ethanol (g) | Standard alcohol unit | How many glasses (or deciliters) of alcoholic beverage contain 5 standard units, which is the maximum amount that can be consumed by an adult woman in one week? |
| 1 glass of beer:  2.5 dl | 5.0 |  |  |  |  |
| 1 glass of wine:  1.5 dl | 13 |  |  |  |  |
| 1 glass of brandy:  0.5 dl | 40 |  |  |  |  |

**Teacher notes for Student sheet 20: Is it worth flambéing with pure alcohol?**

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

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

"Flambéing is a roasting process used when cooking meat, serving desserts and spirits, which is done with flaming spirits... Meat is flambéed at the beginning or end of preparation, or during the preparation of the dish, according to the instructions in certain recipes. [...] A reliable method of flambéing is to heat the alcohol in a ladle or tablespoon over a gas flame, then tilt the spoon slightly, light it, and pour it over the food."

"If possible, use 40% alcohol (vodka, rum, cognac, brandy, whiskey, fruit liqueurs...) to pour over the food." But would it be worthwhile for an enthusiastic beginner to use 96% by volume "pure spirit" in the hope of achieving even better results? Or could those who prefer coconut flavour replace the 40% alcohol beverages listed above with Malibu liqueur, which contains approximately 20% by volume alcohol? In this lesson, you will seek answers to these questions.

**When completing the worksheet, underline or frame the correct text or ~~cross out~~ the incorrect text.**

Watch the video at the following link to see how flambéing is done and complete the text:

<https://www.facebook.com/gundel.restaurant/videos/1729088467127088>

What can we observe during the process? The alcoholic beverage burns with a blue flame.

Meanwhile, the surface of the pancake **burns/does not burn**.

Write down the reaction equation for the complete combustion of ethanol!

C2H5OH + 3 O2 = 2 CO2 + 3 H2O

MATERIALS AND EQUIPMENT: 3 small Petri dishes or beakers, glass rod, tweezers, 3 pieces of paper tissue approx. 2x2 cm, 96% ethanol, tap water in a beaker, 2 10 ml syringes or measuring cylinders, porcelain dish with sand, candle, matches

|  |  |  |
| --- | --- | --- |
| Experiment 1: 96% by volume mixture | Experiment 2: 40% by volume mixture | Experiment 3: 20% by volume mixture |
| 96% alcohol (“pure spirit”), a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. | 4 cm3 of pure spirit diluted to  10 cm3 + a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. | 2 cm3 of pure spirit diluted to  10 cm3 + a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. |

STEPS OF THE EXPERIMENT

1) Dip a piece of paper tissue held with tweezers into the 96% by volume mixture ("pure spirit"), drain it, then try to light it over a bowl of sand.

2) To prepare a mixture of approximately 40% by volume, dilute 4 cm3 of pure spirit with water to 10 cm3 using measuring cylinders or syringes.

3) Dip a piece of paper tissue held with tweezers into the mixture of approximately 40% by volume, then try to ignite it over a bowl of sand.

4) To prepare a mixture of approximately 20% by volume, dilute 2 cm3 of pure spirit with water to 10 cm3 using measuring cylinders or syringes.

5) Dip a piece of paper tissue held with tweezers into the mixture containing approximately 20% by volume, then try to ignite it over a bowl of sand.

1. OBSERVATIONS:

Experiment 1: When the paper tissue is removed from the flame, combustion continues, and then the paper tissue also ignites and burns to ash.

Experiment 2: When the paper tissue is removed from the flame, combustion continues, but the tissue does not ignite.

Experiment 3: When the paper tissue is removed from the flame, no burning is observed.

2. Explanation: In alcoholic beverages (alcohol-water mixtures), **alcohol/water** is the combustible component. Combustion is a **heat-generating/heat-absorbing physical/chemical process**. Combustion is accompanied by the evaporation of the non-combustible component. Evaporation is a **heat-generating/heat-absorbing physical/chemical process**.

Experiment 1: The 96% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 2: The 40% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 3: The 20% mixture **contains/does not contain** enough alcohol to burn, and **contains/does not contain** enough water to absorb the heat.

3. CONCLUSION: The use of 96% pure alcohol **improves/impairs/does not change** the quality of food, **recommended/not recommended** for flambéing. Approximately 20% liqueur **can/cannot be used** for flambéing.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

4. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

The alcohol content of the ethanol-water mixture in % by volume.

5. WHAT WAS THE DEPENDENT VARIABLE?

The flammability of the ethanol-water mixture and the heat released during combustion.

6. HOW COULD YOU TEST THIS DEPENDENT VARIABLE?

We try to light a piece of paper tissue dipped in ethanol-water mixtures and observe the changes that occur.

7. THIS WAS THE ASSUMPTION (HYPOTHESIS):

A minimum alcohol content is required for the ethanol-water mixture to ignite. If there is not enough water in the mixture, the heat generated during combustion may cause the paper tissue to ignite.

8. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X** sign!

☐ The shape of the glass. ☐ The size of the paper tissue.

☐ The volume of the alcoholic mixture. ☒ The quality of the paper tissue.

9. LET’S THINK!

Alcohol is a cell poison and alcoholism is a widespread disease. However, rules for civilized alcohol consumption have developed over the course of human civilization, requiring us to strike a delicate balance:

"*We do not need alcohol to sustain our bodies. Although it has a very high energy content—one gram of alcohol contains 7 kcal/g —it does not provide us with any nutrients, so it is actually unnecessary for us. […] Most of us consider ourselves moderate drinkers and are confident that we will not suffer any damage to our health. However, the actual standard is not based on our subjective assessment, but on the physiological limits of our bodies. Professional recommendations are also based on this. [...] The recommended amount is a maximum of 2 standard drinks per day for adult men and a maximum of 1 standard drink per day for adult women – with at least 2 days off per week. During pregnancy and breastfeeding, it is important for mothers to avoid alcohol consumption, as it hinders the development of the foetus/child. A drink containing 10 grams of alcohol is considered one standard unit. The amounts consumed at home or served in restaurants are usually greater than one unit*.”

How many standard alcohol units does someone consume when drinking the following beverages? Fill in the table! (The density of absolute alcohol is 0.789 g/cm3.)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Volume of 1 glass of alcoholic beverage | Ethanol content  (% by volume) | Volume of ethanol  (ml or cm3) | Mass of ethanol (g) | Standard alcohol unit | How many glasses (or deciliters) of alcoholic beverage contain 5 standard units, which is the maximum amount that can be consumed by an adult woman in one week? |
| 1 glass of beer:  2.5 dl | 5.0 | 250 x 0.05=  12.5 | 12.5 x 0.789≈  10 | ≈1 | 5 : 1≈5 glasses  (5 glasses x 2.5 dl/glass≈12.5 dl) |
| 1 glass of wine:  1.5 dl | 13 | 150 x 0.13=  19.5 | 19.5 x 0.789≈  15 | ≈1.5 | 5 : 1.5≈3.3 glasses  (3.3 glasses x 1.5 dl/glass≈5 dl) |
| 1 glass of brandy:  0.5 dl | 40 | 50 x 0.40=  20 | 20 x 0.789≈  16 | ≈1.6 | 5 : 1.6≈3.1 glasses  (3.1 glasses x 0.5 dl/glass≈1.6 dl) |

**Student sheet 20: Is it worth flambéing with pure alcohol?**

(type 3: experimental design following a scheme version for Group 3 students)

"Flambéing is a roasting process used when cooking meat, serving desserts and spirits, which is done with flaming spirits... Meat is flambéed at the beginning or end of preparation, or during the preparation of the dish, according to the instructions in certain recipes. [...] A reliable method of flambéing is to heat the alcohol in a ladle or tablespoon over a gas flame, then tilt the spoon slightly, light it, and pour it over the food."

"If possible, use 40% alcohol (vodka, rum, cognac, brandy, whiskey, fruit liqueurs...) to pour over the food." But would it be worthwhile for an enthusiastic beginner to use 96% by volume "pure spirit" in the hope of achieving even better results? Or could those who prefer coconut flavour replace the 40% alcohol beverages listed above with Malibu liqueur, which contains approximately 20% by volume alcohol? In this lesson, you will seek answers to these questions.

**When completing the worksheet, underline or frame the correct text or ~~cross out~~ the incorrect text.**

Watch the video at the following link to see how flambéing is done and complete the text:

<https://www.facebook.com/gundel.restaurant/videos/1729088467127088>

What can we observe during the process? The alcoholic beverage ………………………………………………………………………

Meanwhile, the surface of the pancake **burns/does not burn**.

Write down the reaction equation for the complete combustion of ethanol!

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

Design experiments to determine which of the following liquids are suitable for flambéing: 96% by volume pure spirit, 40% by volume rum, and approximately 20% by volume Malibu liqueur. Model the 40% and approx. 20% by volume drinks by diluting pure spirit with water to obtain solutions of approximately these concentrations. When ethyl alcohol and water are mixed, there is a decrease in volume, but you can ignore this in your approximate calculations.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

MATERIALS AND EQUIPMENT: 3 small Petri dishes or beakers, glass rod, tweezers, 3 pieces of paper tissue approx. 2x2 cm, 96% ethanol, tap water in a beaker, 2 10 ml syringes or measuring cylinders, porcelain dish with sand, candle, matches

1. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAVE TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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

2. WHAT IS THE DEPENDENT VARIABLE?

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

3. HOW CAN YOU TEST THIS DEPENDENT VARIABLE? ………………………………………..……………………………………………………….

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

4. THIS IS THE ASSUMPTION (HYPOTHESIS): ………………………………………………………………………………………………………….

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

|  |  |  |
| --- | --- | --- |
| Experiment 1: 96% by volume mixture | Experiment 2: 40% by volume mixture | Experiment 3: 20% by volume mixture |
|  |  |  |

5. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X** sign!

☐ The shape of the glass. ☐ The size of the paper tissue.

☐ The volume of the alcoholic mixture. ☐ The quality of the paper tissue.

6. THE STEPS OF THE EXPERIMENTS: …………………………………………………………………………………………………………………….

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

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

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

**After completing the experiments, write down your observations. Complete the text by entering the appropriate words, by underlining or framing the correct words, or by ~~crossing out~~ the incorrect ones.**

7. OBSERVATIONS:

Experiment 1: ………………………………………………………………………………………………………………………………………………………

Experiment 2: ………………………………………………………………………………………………………………………………………………………

Experiment 3: ………………………………………………………………………………………………………………………………………………………

8. Explanation: In alcoholic beverages (alcohol-water mixtures), **alcohol/water** is the combustible component. Combustion is a **heat-generating/heat-absorbing physical/chemical process**. Combustion is accompanied by the evaporation of the non-combustible component. Evaporation is a **heat-generating/heat-absorbing physical/chemical process**.

Experiment 1: The 96% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 2: The 40% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 3: The 20% mixture **contains/does not contain** enough alcohol to burn, and **contains/does not contain** enough water to absorb the heat.

9. CONCLUSION: The use of 96% pure alcohol **improves/impairs/does not change** the quality of food, **recommended/not recommended** for flambéing. Approximately 20% liqueur **can/cannot be used** for flambéing.

10. LET’S THINK!

Alcohol is a cell poison and alcoholism is a widespread disease. However, rules for civilized alcohol consumption have developed over the course of human civilization, requiring us to strike a delicate balance:

"*We do not need alcohol to sustain our bodies. Although it has a very high energy content—one gram of alcohol contains 7 kcal/g —it does not provide us with any nutrients, so it is actually unnecessary for us. […] Most of us consider ourselves moderate drinkers and are confident that we will not suffer any damage to our health. However, the actual standard is not based on our subjective assessment, but on the physiological limits of our bodies. Professional recommendations are also based on this. [...] The recommended amount is a maximum of 2 standard drinks per day for adult men and a maximum of 1 standard drink per day for adult women – with at least 2 days off per week. During pregnancy and breastfeeding, it is important for mothers to avoid alcohol consumption, as it hinders the development of the foetus/child. A drink containing 10 grams of alcohol is considered one standard unit. The amounts consumed at home or served in restaurants are usually greater than one unit*.”

How many standard alcohol units does someone consume when drinking the following beverages? Fill in the table! (The density of absolute alcohol is 0.789 g/cm3.)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Volume of 1 glass of alcoholic beverage | Ethanol content  (% by volume) | Volume of ethanol  (ml or cm3) | Mass of ethanol (g) | Standard alcohol unit | How many glasses (or deciliters) of alcoholic beverage contain 5 standard units, which is the maximum amount that can be consumed by an adult woman in one week? |
| 1 glass of beer:  2.5 dl | 5.0 |  |  |  |  |
| 1 glass of wine:  1.5 dl | 13 |  |  |  |  |
| 1 glass of brandy:  0.5 dl | 40 |  |  |  |  |

**Teacher notes for Student sheet 20: Is it worth flambéing with pure alcohol?**

(type 3: experimental design following a scheme version for Group 3 students)

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

"Flambéing is a roasting process used when cooking meat, serving desserts and spirits, which is done with flaming spirits... Meat is flambéed at the beginning or end of preparation, or during the preparation of the dish, according to the instructions in certain recipes. [...] A reliable method of flambéing is to heat the alcohol in a ladle or tablespoon over a gas flame, then tilt the spoon slightly, light it, and pour it over the food."

"If possible, use 40% alcohol (vodka, rum, cognac, brandy, whiskey, fruit liqueurs...) to pour over the food." But would it be worthwhile for an enthusiastic beginner to use 96% by volume "pure spirit" in the hope of achieving even better results? Or could those who prefer coconut flavour replace the 40% alcohol beverages listed above with Malibu liqueur, which contains approximately 20% by volume alcohol? In this lesson, you will seek answers to these questions.

**When completing the worksheet, underline or frame the correct text or ~~cross out~~ the incorrect text.**

Watch the video at the following link to see how flambéing is done and complete the text:

<https://www.facebook.com/gundel.restaurant/videos/1729088467127088>

What can we observe during the process? The alcoholic beverage burns with a blue flame.

Meanwhile, the surface of the pancake **burns/does not burn**.

Write down the reaction equation for the complete combustion of ethanol!

C2H5OH + 3 O2 = 2 CO2 + 3 H2O

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

1. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAVE TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

The alcohol content of the ethanol-water mixture in % by volume.

2. WHAT IS THE DEPENDENT VARIABLE

The flammability of the ethanol-water mixture and the heat released during combustion.

3. HOW CAN YOU TEST THIS DEPENDENT VARIABLE?

We try to light a piece of paper tissue dipped in ethanol-water mixtures and observe the changes that occur

4. THIS IS THE ASSUMPTION (HYPOTHESIS):

A minimum alcohol content is required for the ethanol-water mixture to ignite. If there is not enough water in the mixture, the heat generated during combustion may cause the paper tissue to ignite.

|  |  |  |
| --- | --- | --- |
| Experiment 1: 96% by volume mixture | Experiment 2: 40% by volume mixture | Experiment 3: 20% by volume mixture |
| 96% alcohol (“pure spirit”), a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. | 4 cm3 of pure spirit diluted to  10 cm3 + a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. | 2 cm3 of pure spirit diluted to  10 cm3 + a piece of paper tissue dipped in it, drained, then held over a flame and removed from the flame. |

5. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X** sign!

☐ The shape of the glass. ☐ The size of the paper tissue.

☐ The volume of the alcoholic mixture. ☒ The quality of the paper tissue.

6. THE STEPS OF THE EXPERIMENTS:

1) Dip a piece of paper tissue held with tweezers into the 96% by volume mixture ("pure spirit"), drain it, then try to light it over a bowl of sand.

2) To prepare a mixture of approximately 40% by volume, dilute 4 cm3 of pure spirit with water to 10 cm3 using measuring cylinders or syringes.

3) Dip a piece of paper tissue held with tweezers into the mixture of approximately 40% by volume, then try to ignite it over a bowl of sand.

4) To prepare a mixture of approximately 20% by volume, dilute 2 cm3 of pure spirit with water to 10 cm3 using measuring cylinders or syringes.

5) Dip a piece of paper tissue held with tweezers into the mixture containing approximately 20% by volume, then try to ignite it over a bowl of sand.

7. OBSERVATIONS:

Experiment 1: When the paper tissue is removed from the flame, combustion continues, and then the paper tissue also ignites and burns to ash.

Experiment 2: When the paper tissue is removed from the flame, combustion continues, but the tissue does not ignite.

Experiment 3: When the paper tissue is removed from the flame, no burning is observed.

8. Explanation: In alcoholic beverages (alcohol-water mixtures), **alcohol/water** is the combustible component. Combustion is a **heat-generating/heat-absorbing physical/chemical process**. Combustion is accompanied by the evaporation of the non-combustible component. Evaporation is a **heat-generating/heat-absorbing physical/chemical process**.

Experiment 1: The 96% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 2: The 40% mixture **contains/does not contain** enough alcohol for the mixture to burn, and **contains/does not contain** enough water to absorb the heat.

Experiment 3: The 20% mixture **contains/does not contain** enough alcohol to burn, and **contains/does not contain** enough water to absorb the heat.

9. CONCLUSION: The use of 96% pure alcohol **improves/impairs/does not change** the quality of food, **recommended/not recommended** for flambéing. Approximately 20% liqueur **can/cannot be used** for flambéing.

10. LET’S THINK!

Alcohol is a cell poison and alcoholism is a widespread disease. However, rules for civilized alcohol consumption have developed over the course of human civilization, requiring us to strike a delicate balance:

"*We do not need alcohol to sustain our bodies. Although it has a very high energy content—one gram of alcohol contains 7 kcal/g —it does not provide us with any nutrients, so it is actually unnecessary for us. […] Most of us consider ourselves moderate drinkers and are confident that we will not suffer any damage to our health. However, the actual standard is not based on our subjective assessment, but on the physiological limits of our bodies. Professional recommendations are also based on this. [...] The recommended amount is a maximum of 2 standard drinks per day for adult men and a maximum of 1 standard drink per day for adult women – with at least 2 days off per week. During pregnancy and breastfeeding, it is important for mothers to avoid alcohol consumption, as it hinders the development of the foetus/child. A drink containing 10 grams of alcohol is considered one standard unit. The amounts consumed at home or served in restaurants are usually greater than one unit*.”

How many standard alcohol units does someone consume when drinking the following beverages? Fill in the table! (The density of absolute alcohol is 0.789 g/cm3.)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Volume of 1 glass of alcoholic beverage | Ethanol content  (% by volume) | Volume of ethanol  (ml or cm3) | Mass of ethanol (g) | Standard alcohol unit | How many glasses (or deciliters) of alcoholic beverage contain 5 standard units, which is the maximum amount that can be consumed by an adult woman in one week? |
| 1 glass of beer:  2.5 dl | 5.0 | 250 x 0.05=  12.5 | 12.5 x 0.789≈  10 | ≈1 | 5 : 1≈5 glasses  (5 glasses x 2.5 dl/glass≈12.5 dl) |
| 1 glass of wine:  1.5 dl | 13 | 150 x 0.13=  19.5 | 19.5 x 0.789≈  15 | ≈1.5 | 5 : 1.5≈3.3 glasses  (3.3 glasses x 1.5 dl/glass≈5 dl) |
| 1 glass of brandy:  0.5 dl | 40 | 50 x 0.40=  20 | 20 x 0.789≈  16 | ≈1.6 | 5 : 1.6≈3.1 glasses  (3.1 glasses x 0.5 dl/glass≈1.6 dl) |

END OF THE 20th STUDENT SHEETS AND TEACHER NOTES

**Student sheet 21. The sweet secret of zero cola**

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

**Healthy lifestyles** are receiving increasing attention these days. Many people are trying to eat a **balanced diet** and **reduce their sugar intake** in order to avoid **various health risks**, such as **diabetes** and **heart disease**. As a result, more and more people are looking for **lower-sugar or sugar-free** alternatives. The popularity of zero cola is also due to the fact that it is a **sugar- and calorie-free** soft drink, making it attractive to those who are **watching their energy intake** or want to **lose weight**.

**Conduct an experiment to determine whether the manufacturer's claim that zero cola does not contain glucose.**

MATERIALS AND EQUIPMENT: original cola in beaker No. 1, zero cola in beaker No. 2, Fehling I and Fehling II reagents, plastic tray, 2 test tubes, test tube rack, test tube clamp, spirit burner or gas burner, matches

|  |  |
| --- | --- |
| Experiment I.:  Fehling I reagent + Fehling II reagent + original cola + heating | Experiment II.:  Fehling I reagent + Fehling II reagent + zero cola + heating |

STEPS OF THE EXPERIMENT:

(1) Pour a finger's width (approx. 2-2 cm3) of Fehling I reagent into both test tubes.

(2) While shaking from time to time, add enough Fehling II reagent to the contents of both test tubes to dissolve the precipitate that forms.

(3) Then pour a finger's width (approx. 2 cm3) of original cola into test tube 1 and a finger's width of zero cola into test tube 2, then shake the contents of both test tubes together.

(4) Carefully heat the contents of both test tubes to boiling point while shaking continuously.

**After completing the experiments, write down your observations and explanations. Draw conclusions as well. Complete the text by filling in the appropriate words and underlining the correct words!**

1. OBSERVATION:

Experiment I.: …………………………………………………………………………………………………………………………………….………………..

Experiment II.: ……………………………………………………………………………………………………………………………………………………..

2. EXPLANATION:

Experiment I.: …………………………………………………………………………………………………………………………………….………………..

Experiment II.: ……………………………………………………………………………………………………………………………………………………..

3. Write down the Fehling test equation with glucose. Name the products. In the structural formula of the organic product, circle the atom that has been incorporated into the glucose molecule!

A képen Betűtípus, szöveg, sor, fehér látható

Automatikusan generált leírás

+ + = + +

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

4. CONCLUSION: The manufacturer **rightly/wrongly** claims that zero cola does not contain glucose. The

molecules of the sweeteners found in zero cola do not contain the ………………….. group, so they cannot reduce Cu2+ ions in the Fehling test.

5. LET’S THINK!

The sweet taste of zero-calorie cola comes from three artificial sweeteners: sodium cyclamate, aspartame, and acesulfame K. Since the consumption of artificial sweeteners involves little or no energy intake, it is commonly believed that they can help control body weight without having to give up sweet flavours. However, according to the latest recommendation from the World Health Organization (WHO), the use of artificial sweeteners does not have long-term benefits in terms of reducing body fat. In fact, according to the recommendation, long-term use of artificial sweeteners may have undesirable effects, such as cardiovascular disease, insulin resistance, and type 2 diabetes. In addition, the phosphoric acid found in cola can cause tooth enamel to thin, which can lead to tooth decay.

What effect can sugary and sugar-free soft drinks have on the body? Complete the flowchart by filling in the missing letters.

A) Increased insulin production B) Soft drinks that do not contain glucose C) Weight gain, risk of diabetes

D) Insulin production remains unchanged E) High glucose content F) No increase in blood sugar levels

G) Insulin resistance, cardiovascular diseases

To your knowledge, how can the health risks of foods containing natural or artificial sweeteners be reduced?

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**Teacher notes for Student sheet 21: The sweet secret of zero cola**

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

Teachers are kindly asked to encourage their students to do experiments by highlighting the importance of experimentation in science and praising them when they think correctly.

**Healthy lifestyles** are receiving increasing attention these days. Many people are trying to eat a **balanced diet** and **reduce their sugar intake** in order to avoid **various health risks**, such as **diabetes** and **heart disease**. As a result, more and more people are looking for **lower-sugar or sugar-free** alternatives. The popularity of zero cola is also due to the fact that it is a **sugar- and calorie-free** soft drink, making it attractive to those who are **watching their energy intake** or want to **lose weight**.

**Conduct an experiment to determine whether the manufacturer's claim that zero cola does not contain glucose.**

MATERIALS AND EQUIPMENT: original cola in beaker No. 1, zero cola in beaker No. 2, Fehling I and Fehling II reagents, plastic tray, 2 test tubes, test tube rack, test tube clamp, spirit burner or gas burner, matches

|  |  |
| --- | --- |
| Experiment I.:  Fehling I reagent + Fehling II reagent + original cola + heating | Experiment II.:  Fehling I reagent + Fehling II reagent + zero cola + heating |

STEPS OF THE EXPERIMENT:

(1) Pour a finger's width (approx. 2-2 cm3) of Fehling I reagent into both test tubes.

(2) While shaking from time to time, add enough Fehling II reagent to the contents of both test tubes to dissolve the precipitate that forms.

(3) Then pour a finger's width (approx. 2 cm3) of original cola into test tube 1 and a finger's width of zero cola into test tube 2, then shake the contents of both test tubes together.

(4) Carefully heat the contents of both test tubes to boiling point while shaking continuously.

**After completing the experiments, write down your observations and explanations. Draw conclusions as well. Complete the text by filling in the appropriate words and underlining the correct words!**

1. OBSERVATION:

Experiment I.: A brick-red precipitate formed in test tube 1.

Experiment II.: No change was observed in test tube 2.

2. EXPLANATION:

Experiment I.: The glucose reduced the Cu2+ ions in the solution to Cu+ ions, resulting in the formation of Cu2O precipitate.

Experiment II.: The artificial sweeteners in zero cola did not react with the Cu2+ ions.

3. Write down the Fehling test equation with glucose. Name the products. In the structural formula of the organic product, circle the atom that has been incorporated into the glucose molecule!

A képen Betűtípus, szöveg, sor, fehér látható

Automatikusan generált leírásA képen Betűtípus, szöveg, tervezés látható

Automatikusan generált leírás

+2 Cu2++4 OH= + Cu2O + 2 H2O

gluconic acid copper(I)-oxide water

4. CONCLUSION: The manufacturer **rightly/wrongly** claims that zero cola does not contain glucose. The

molecules of the sweeteners found in zero cola do not contain the formyl group, so they cannot reduce Cu2+ ions in the Fehling test.

5. LET’S THINK!

The sweet taste of zero-calorie cola comes from three artificial sweeteners: sodium cyclamate, aspartame, and acesulfame K. Since the consumption of artificial sweeteners involves little or no energy intake, it is commonly believed that they can help control body weight without having to give up sweet flavours. However, according to the latest recommendation from the World Health Organization (WHO), the use of artificial sweeteners does not have long-term benefits in terms of reducing body fat. In fact, according to the recommendation, long-term use of artificial sweeteners may have undesirable effects, such as cardiovascular disease, insulin resistance, and type 2 diabetes. In addition, the phosphoric acid found in cola can cause tooth enamel to thin, which can lead to tooth decay.

What effect can sugary and sugar-free soft drinks have on the body? Complete the flowchart by filling in the missing letters.

A) Increased insulin production B) Soft drinks that do not contain glucose C) Weight gain, risk of diabetes

D) Insulin production remains unchanged E) High glucose content F) No increase in blood sugar levels

G) Insulin resistance, cardiovascular diseases

To your knowledge, how can the health risks of foods containing natural or artificial sweeteners be reduced?

Foods containing natural sugars (e.g., fruits) should be preferred, while foods containing added natural or artificial sweeteners should be avoided. Regular exercise is also very important, as it burns off some of the energy consumed.

**Student sheet 21: The sweet secret of zero cola**

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

**Healthy lifestyles** are receiving increasing attention these days. Many people are trying to eat a **balanced diet** and **reduce their sugar intake** in order to avoid **various health risks**, such as **diabetes** and **heart disease**. As a result, more and more people are looking for **lower-sugar or sugar-free** alternatives. The popularity of zero cola is also due to the fact that it is a **sugar- and calorie-free** soft drink, making it attractive to those who are **watching their energy intake** or want to **lose weight**.

**Conduct an experiment to determine whether the manufacturer's claim that zero cola does not contain glucose.**

MATERIALS AND EQUIPMENT: original cola in beaker No. 1, zero cola in beaker No. 2, Fehling I and Fehling II reagents, plastic tray, 2 test tubes, test tube rack, test tube clamp, spirit burner or gas burner, matches

|  |  |
| --- | --- |
| Experiment I.:  Fehling I reagent + Fehling II reagent + original cola + heating | Experiment II.:  Fehling I reagent + Fehling II reagent + zero cola + heating |

STEPS OF THE EXPERIMENT:

(1) Pour a finger's width (approx. 2-2 cm3) of Fehling I reagent into both test tubes.

(2) While shaking from time to time, add enough Fehling II reagent to the contents of both test tubes to dissolve the precipitate that forms.

(3) Then pour a finger's width (approx. 2 cm3) of original cola into test tube 1 and a finger's width of zero cola into test tube 2, then shake the contents of both test tubes together.

(4) Carefully heat the contents of both test tubes to boiling point while shaking continuously.

**After completing the experiments, write down your observations and explanations. Draw conclusions as well. Complete the text by filling in the appropriate words and underlining the correct words!**

1. OBSERVATION:

Experiment I.: …………………………………………………………………………………………………………………………………….………………..

Experiment II.: ……………………………………………………………………………………………………………………………………………………..

2. EXPLANATION:

Experiment I.: …………………………………………………………………………………………………………………………………….………………..

Experiment II.: ……………………………………………………………………………………………………………………………………………………..

3. Write down the Fehling test equation with glucose. Name the products. In the structural formula of the organic product, circle the atom that has been incorporated into the glucose molecule!

A képen Betűtípus, szöveg, sor, fehér látható

Automatikusan generált leírás

+ + = + +

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

4. CONCLUSION: The manufacturer **rightly/wrongly** claims that zero cola does not contain glucose. The

molecules of the sweeteners found in zero cola do not contain the ………………….. group, so they cannot reduce Cu2+ ions in the Fehling test.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

5. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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6. WHAT WAS THE DEPENDENT VARIABLE?

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7. HOW COULD YOU TEST THIS DEPENDENT VARIABLE? ……………………………………………………………………………………….

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

8. THIS WAS THE ASSUMPTION (HYPOTHESIS):

If …………………………………………………………………..…………………………………………………………………………. (the independent

variable changes as intended), then ……………………………………………………………………………………………. (the dependent variable will change in this way).

9. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with a **x** sign!

The size of the test tubes  The volume of the Fehling I reagent  The volume of the Fehling II reagent

The volume of the cola samples  The timing of the experiment  The time of heating

The person conducting the experiment

10. LET’S THINK!

The sweet taste of zero-calorie cola comes from three artificial sweeteners: sodium cyclamate, aspartame, and acesulfame K. Since the consumption of artificial sweeteners involves little or no energy intake, it is commonly believed that they can help control body weight without having to give up sweet flavours. However, according to the latest recommendation from the World Health Organization (WHO), the use of artificial sweeteners does not have long-term benefits in terms of reducing body fat. In fact, according to the recommendation, long-term use of artificial sweeteners may have undesirable effects, such as cardiovascular disease, insulin resistance, and type 2 diabetes. In addition, the phosphoric acid found in cola can cause tooth enamel to thin, which can lead to tooth decay.

What effect can sugary and sugar-free soft drinks have on the body? Complete the flowchart by filling in the missing letters.

A) Increased insulin production B) Soft drinks that do not contain glucose C) Weight gain, risk of diabetes

D) Insulin production remains unchanged E) High glucose content F) No increase in blood sugar levels

G) Insulin resistance, cardiovascular diseases

To your knowledge, how can the health risks of foods containing natural or artificial sweeteners be reduced?

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**Teacher notes for Student sheet 21: The sweet secret of zero cola**

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

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

**Healthy lifestyles** are receiving increasing attention these days. Many people are trying to eat a **balanced diet** and **reduce their sugar intake** in order to avoid **various health risks**, such as **diabetes** and **heart disease**. As a result, more and more people are looking for **lower-sugar or sugar-free** alternatives. The popularity of zero cola is also due to the fact that it is a **sugar- and calorie-free** soft drink, making it attractive to those who are **watching their energy intake** or want to **lose weight**.

**Conduct an experiment to determine whether the manufacturer's claim that zero cola does not contain glucose.**

MATERIALS AND EQUIPMENT: original cola in beaker No. 1, zero cola in beaker No. 2, Fehling I and Fehling II reagents, plastic tray, 2 test tubes, test tube rack, test tube clamp, spirit burner or gas burner, matches

|  |  |
| --- | --- |
| Experiment I.:  Fehling I reagent + Fehling II reagent + original cola + heating | Experiment II.:  Fehling I reagent + Fehling II reagent + zero cola + heating |

STEPS OF THE EXPERIMENT:

(1) Pour a finger's width (approx. 2-2 cm3) of Fehling I reagent into both test tubes.

(2) While shaking from time to time, add enough Fehling II reagent to the contents of both test tubes to dissolve the precipitate that forms.

(3) Then pour a finger's width (approx. 2 cm3) of original cola into test tube 1 and a finger's width of zero cola into test tube 2, then shake the contents of both test tubes together.

(4) Carefully heat the contents of both test tubes to boiling point while shaking continuously.

**After completing the experiments, write down your observations and explanations. Draw conclusions as well. Complete the text by filling in the appropriate words and underlining the correct words!**

1. OBSERVATION:

Experiment I.: A brick-red precipitate formed in test tube 1.

Experiment II.: No change was observed in test tube 2.

2. EXPLANATION:

Experiment I.: The glucose reduced the Cu2+ ions in the solution to Cu+ ions, resulting in the formation of Cu2O precipitate.

Experiment II.: The artificial sweeteners in zero cola did not react with the Cu2+ ions.

3. Write down the Fehling test equation with glucose. Name the products. In the structural formula of the organic product, circle the atom that has been incorporated into the glucose molecule!

A képen Betűtípus, szöveg, sor, fehér látható

Automatikusan generált leírásA képen Betűtípus, szöveg, tervezés látható

Automatikusan generált leírás

+2 Cu2++4 OH= + Cu2O + 2 H2O

gluconic acid copper(I)-oxide water

4. CONCLUSION: The manufacturer **rightly/wrongly** claims that zero cola does not contain glucose. The

molecules of the sweeteners found in zero cola do not contain the formyl group, so they cannot reduce Cu2+ ions in the Fehling test.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

5. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

Type of drink (original cola or zero cola).

6. WHAT WAS THE DEPENDENT VARIABLE?

The presence or absence of glucose.

7. HOW COULD YOU TEST THIS DEPENDENT VARIABLE?

We performed the Fehling test on both drinks and observed whether a brick-red precipitate formed in the test tube, indicating the presence of glucose.

8. THIS WAS THE ASSUMPTION (HYPOTHESIS):

If zero cola does not contain glucose (the independent variable changes as intended), then no brick-red precipitate is formed during the Fehling test (the dependent variable will change in this way).

9. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with a **x** sign!

The size of the test tubes  The volume of the Fehling I reagent  The volume of the Fehling II reagent

The volume of the cola samples  The timing of the experiment  The time of heating

The person conducting the experiment

10. LET’S THINK!

The sweet taste of zero-calorie cola comes from three artificial sweeteners: sodium cyclamate, aspartame, and acesulfame K. Since the consumption of artificial sweeteners involves little or no energy intake, it is commonly believed that they can help control body weight without having to give up sweet flavours. However, according to the latest recommendation from the World Health Organization (WHO), the use of artificial sweeteners does not have long-term benefits in terms of reducing body fat. In fact, according to the recommendation, long-term use of artificial sweeteners may have undesirable effects, such as cardiovascular disease, insulin resistance, and type 2 diabetes. In addition, the phosphoric acid found in cola can cause tooth enamel to thin, which can lead to tooth decay.

What effect can sugary and sugar-free soft drinks have on the body? Complete the flowchart by filling in the missing letters.

A) Increased insulin production B) Soft drinks that do not contain glucose C) Weight gain, risk of diabetes

D) Insulin production remains unchanged E) High glucose content F) No increase in blood sugar levels

G) Insulin resistance, cardiovascular diseases

To your knowledge, how can the health risks of foods containing natural or artificial sweeteners be reduced?

Foods containing natural sugars (e.g., fruits) should be preferred, while foods containing added natural or artificial sweeteners should be avoided. Regular exercise is also very important, as it burns off some of the energy consumed.

**Student sheet 21: The sweet secret of zero cola**

(type 3: experimental design following a scheme version for Group 3 students)

**Healthy lifestyles** are receiving increasing attention these days. Many people are trying to eat a **balanced diet** and **reduce their sugar intake** in order to avoid **various health risks**, such as **diabetes** and **heart disease**. As a result, more and more people are looking for **lower-sugar or sugar-free** alternatives. The popularity of zero cola is also due to the fact that it is a **sugar- and calorie-free** soft drink, making it attractive to those who are **watching their energy intake** or want to **lose weight**.

**Design an experiment to determine whether the manufacturer's claim that zero cola does not contain glucose (scientifically known as glucose) is true.**

MATERIALS AND EQUIPMENT: original cola in beaker No. 1, zero cola in beaker No. 2, Fehling I and Fehling II reagents, plastic tray, 2 test tubes, test tube rack, test tube clamp, spirit burner or gas burner, matches

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

1. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAVE TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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

2. WHAT IS THE DEPENDENT VARIABLE? …………………………………………………………………………………………………………………….

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3. HOW CAN YOU TEST THIS DEPENDENT VARIABLE? ………………………………………..……………………………………………………….

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4. THIS IS THE ASSUMPTION (HYPOTHESIS):

If …………………………………………………………………..…………………………………………………………………………. (the independent

variable changes as intended), then ……………………………………………………………………………………………. (the dependent variable will change in this way).

5. HOW CAN THE INDEPENDENT VARIABLES CHANGE? Plan what needs to be done in the individual tubes!

|  |  |
| --- | --- |
| Experiment I.: | Experiment II.: |
| number of repetitions in class: | number of repetitions in class: |

6. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with a **x** sign!

The size of the test tubes  The volume of the Fehling I reagent  The volume of the Fehling II reagent

The volume of the cola samples  The timing of the experiment  The time of heating

The person conducting the experiment

7. THE STEPS OF THE EXPERIMENTS: .……………………………………………………………………………………………………………………

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**After completing the experiments, write down your observations and explanations. Draw conclusions as well. Complete the text by filling in the appropriate words and underlining the correct words!**

8. OBSERVATION:

Experiment I.: …………………………………………………………………………………………………………………………………….………………..

Experiment II.: ……………………………………………………………………………………………………………………………………………………..

9. EXPLANATION:

Experiment I.: …………………………………………………………………………………………………………………………………….………………..

Experiment II.: ……………………………………………………………………………………………………………………………………………………..

10. Write down the Fehling test equation with glucose. Name the products. In the structural formula of the organic product, circle the atom that has been incorporated into the glucose molecule!

A képen Betűtípus, szöveg, sor, fehér látható

Automatikusan generált leírás

+ + = + +

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

11. CONCLUSION: The manufacturer **rightly/wrongly** claims that zero cola does not contain glucose. The

molecules of the sweeteners found in zero cola do not contain the ………………….. group, so they cannot reduce Cu2+ ions in the Fehling test.

12. LET’S THINK!

The sweet taste of zero-calorie cola comes from three artificial sweeteners: sodium cyclamate, aspartame, and acesulfame K. Since the consumption of artificial sweeteners involves little or no energy intake, it is commonly believed that they can help control body weight without having to give up sweet flavours. However, according to the latest recommendation from the World Health Organization (WHO), the use of artificial sweeteners does not have long-term benefits in terms of reducing body fat. In fact, according to the recommendation, long-term use of artificial sweeteners may have undesirable effects, such as cardiovascular disease, insulin resistance, and type 2 diabetes. In addition, the phosphoric acid found in cola can cause tooth enamel to thin, which can lead to tooth decay.

What effect can sugary and sugar-free soft drinks have on the body? Complete the flowchart by filling in the missing letters.

A) Increased insulin production B) Soft drinks that do not contain glucose C) Weight gain, risk of diabetes

D) Insulin production remains unchanged E) High glucose content F) No increase in blood sugar levels

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To your knowledge, how can the health risks of foods containing natural or artificial sweeteners be reduced?

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**Teacher notes for Student sheet 21: The sweet secret of zero cola**

(type 3: experimental design following a scheme version for Group 3 students)

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

**Healthy lifestyles** are receiving increasing attention these days. Many people are trying to eat a **balanced diet** and **reduce their sugar intake** in order to avoid **various health risks**, such as **diabetes** and **heart disease**. As a result, more and more people are looking for **lower-sugar or sugar-free** alternatives. The popularity of zero cola is also due to the fact that it is a **sugar- and calorie-free** soft drink, making it attractive to those who are **watching their energy intake** or want to **lose weight**.

**Design an experiment to determine whether the manufacturer's claim that zero cola does not contain glucose (scientifically known as glucose) is true.**

MATERIALS AND EQUIPMENT: original cola in beaker No. 1, zero cola in beaker No. 2, Fehling I and Fehling II reagents, plastic tray, 2 test tubes, test tube rack, test tube clamp, spirit burner or gas burner, matches

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

1. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAVE TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

Type of drink (original cola or zero cola).

2. WHAT IS THE DEPENDENT VARIABLE?

The presence or absence of glucose.

3. HOW CAN YOU TEST THIS DEPENDENT VARIABLE?

We perform the Fehling test on both drinks and observe whether a brick-red precipitate formed in the test tube, indicating the presence of glucose.

4. THIS IS THE ASSUMPTION (HYPOTHESIS):

If zero cola does not contain glucose (the independent variable changes as intended), then no brick-red precipitate is formed during the Fehling test (the dependent variable will change in this way).

5. HOW CAN THE INDEPENDENT VARIABLES CHANGE? Plan what needs to be done in the individual tubes!

|  |  |
| --- | --- |
| Experiment I.:  Fehling I reagent + Fehling II reagent + original cola + heating | Experiment II.:  Fehling I reagent + Fehling II reagent + zero cola + heating |
| number of repetitions in class: | number of repetitions in class: |

6. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with a **x** sign!

The size of the test tubes  The volume of the Fehling I reagent  The volume of the Fehling II reagent

The volume of the cola samples  The timing of the experiment  The time of heating

The person conducting the experiment

7. THE STEPS OF THE EXPERIMENTS:

(1) Pour a finger's width (approx. 2-2 cm3) of Fehling I reagent into both test tubes.

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(3) Then pour a finger's width (approx. 2 cm3) of original cola into test tube 1 and a finger's width of zero cola into test tube 2, then shake the contents of both test tubes together.

(4) Carefully heat the contents of both test tubes to boiling point while shaking continuously.

**After completing the experiments, write down your observations and explanations. Draw conclusions as well. Complete the text by filling in the appropriate words and underlining the correct words!**

8. OBSERVATION:

Experiment I.: A brick-red precipitate formed in test tube 1.

Experiment II.: No change was observed in test tube 2.

9. EXPLANATION:

Experiment I.: The glucose reduced the Cu2+ ions in the solution to Cu+ ions, resulting in the formation of Cu2O precipitate.

Experiment II.: The artificial sweeteners in zero cola did not react with the Cu2+ ions.

10. Write down the Fehling test equation with glucose. Name the products. In the structural formula of the organic product, circle the atom that has been incorporated into the glucose molecule!

A képen Betűtípus, szöveg, sor, fehér látható

Automatikusan generált leírásA képen Betűtípus, szöveg, tervezés látható

Automatikusan generált leírás

+2 Cu2++4 OH= + Cu2O + 2 H2O

gluconic acid copper(I)-oxide water

11. CONCLUSION: The manufacturer **rightly/wrongly** claims that zero cola does not contain glucose. The

molecules of the sweeteners found in zero cola do not contain the formyl group, so they cannot reduce Cu2+ ions in the Fehling test.

12. LET’S THINK!

The sweet taste of zero-calorie cola comes from three artificial sweeteners: sodium cyclamate, aspartame, and acesulfame K. Since the consumption of artificial sweeteners involves little or no energy intake, it is commonly believed that they can help control body weight without having to give up sweet flavours. However, according to the latest recommendation from the World Health Organization (WHO), the use of artificial sweeteners does not have long-term benefits in terms of reducing body fat. In fact, according to the recommendation, long-term use of artificial sweeteners may have undesirable effects, such as cardiovascular disease, insulin resistance, and type 2 diabetes. In addition, the phosphoric acid found in cola can cause tooth enamel to thin, which can lead to tooth decay.

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A) Increased insulin production B) Soft drinks that do not contain glucose C) Weight gain, risk of diabetes

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To your knowledge, how can the health risks of foods containing natural or artificial sweeteners be reduced?

Foods containing natural sugars (e.g., fruits) should be preferred, while foods containing added natural or artificial sweeteners should be avoided. Regular exercise is also very important, as it burns off some of the energy consumed.

END OF THE 21st STUDENT SHEETS AND TEACHER NOTES

**Student sheet 22: How much vitamin C is there in orange juice?**

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

Vitamin C (chemically known as ascorbic acid) is necessary for strengthening bones and teeth, producing collagen, and maintaining a healthy immune system. Its deficiency causes scurvy, which once killed many sailors who did not have access to fresh fruit and vegetables during long voyages. As an antioxidant, vitamin C can also reduce the risk of cancer, high blood pressure, heart disease, and age-related vision loss, as it oxidizes easily, meaning it transfers electrons to free radicals with unpaired electrons. By transferring its own electrons, vitamin C prevents aggressive free radicals from "stealing" electrons from our vital molecules (e.g., DNA, proteins), rendering them inoperable. Free radicals are also produced in our bodies, but their quantity is increased by factors such as UV radiation, smoking, alcohol consumption, drug use, and smog.

Our bodies cannot produce vitamin C. On average, we need to consume approximately 80 mg of vitamin C per day. The boxes of various brands of orange juice sold in stores indicate how many milligrams of vitamin C are contained in 100 millilitres. Now you will determine whether this statement is true for the orange juice samples on your trays. Ascorbic acid reacts with iodine according to the following equation:



**Complete the text by entering the appropriate words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones!**

During the chemical reaction, the ascorbic acid molecule (i.e., vitamin C) **donates/accepts electrons**, thus it **is** **oxidized/reduced**, i.e., acting as an **oxidizing agent/reducing agent**.

MATERIALS AND EQUIPMENT: 1% starch solution; Lugol's solution; 2 Pasteur pipettes (marked "S" and "L") or dropper bottles marked "S" and "L" for the starch solution and Lugol's solution, respectively; 2 x 100 cm3 beakers marked "S" and "L" for the starch solution and Lugol's solution, respectively; 50 cm3 of distilled water in a

100 cm3 beaker marked with the number 1; 50 cm3 of distilled water in a 100 cm3 beaker marked with the number 2; half a vitamin C effervescent tablet (80 mg vitamin C/tablet); 50 cm3 of store-bought orange juice in a 100 cm3 beaker marked with the number 3; a wipe or paper towel; a tray; 3 glass rods or spoons; protective gloves and goggles.

**Experiment I.**: There is 50 cm3 of distilled water in beaker No. 1. Add 2 cm3 of starch solution using the Pasteur pipette marked "S", then add 1 drop of Lugol's solution using the Pasteur pipette marked "L."

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

**Explanation**: Iodine reacts with starch to produce a ………………………...… color. If the solution is more concentrated, the color appears black.

**Experiment II.**: Dissolve half of an effervescent tablet containing 80 mg of vitamin C in 50 cm3 of distilled water in beaker No. 2. Add 2 cm3 of starch solution to the solution using the Pasteur pipette marked "S". Then, using the Pasteur pipette marked "L", add Lugol's solution to the ascorbic acid solution while stirring. Count how many drops of Lugol's solution are needed to achieve the desired color change.

**Observation**: ………………… drops of Lugol's solution changed permanently the color of the solution.

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

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

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

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

**Conclusion:** Based on the above, it can be calculated that 1 drop of Lugol's solution reacts with ……………….. mg of ascorbic acid.

**Experiment III.**: The box of store-bought orange juice in beaker No. 3 states that 100 milliliters of the beverage

contains …….. mg of vitamin C. Based on the results of the previous experiments, the following experiment can be used to determine whether the orange juice contains the amount of vitamin C stated on the box.

THE STEPS OF THE EXPERIMENTS:

(1) Add 2 cm3 of starch solution to the orange juice in beaker No. 3 using the Pasteur pipette marked "S".

(2) While stirring, add Lugol's solution to the orange juice using the Pasteur pipette marked "L".

(3) Count how many drops of Lugol's solution are needed to achieve the remaining color change!

1. OBSERVATIONS: ……………….. drops of Lugol's solution permanently changed the color of the solution.

2. Explanation: In Experiment II., 1 drop of Lugol's solution reacted with ……………….. mg of ascorbic acid.

Therefore, in Experiment III., the iodine in ……………….. drops of Lugol's solution reacted with approximately

……………….. mg of ascorbic acid.

3. CONCLUSION: 50 cm3 of orange juice contains …………………….….. mg of ascorbic acid, i.e. vitamin C. Therefore,

100 cm3 of orange juice contains ……………….. mg of vitamin C. Considering that measurements taken with such simple tools are highly inaccurate, this value is a **fairly good approximation/not close** to the vitamin C content indicated on the box. (Since vitamin C is unstable, it is also possible that the manufacturer adds more vitamin C to the orange juice so that there are no problems during quality control.)

4. LET'S THINK!

Linus Carl Pauling, who won the Nobel Prize in Chemistry in 1954 for his achievements in researching the nature of chemical bonds, suffered from what is known as "Nobel Prize disease." This is the name given to the phenomenon whereby scientists who have made genuine scientific breakthroughs imagine that they are also experts in fields of science in which they have no expertise. Pauling, for example, recommended the use of megadoses of vitamin C (i.e. 3000 mg per day), but the positive effects of this have not been confirmed by medical research since then. Fortunately for those who follow Pauling's advice, vitamin C is water-soluble, so any excess is excreted from the body in urine, although it does increase the risk of kidney stones. Water-soluble vitamins also include B vitamins, which contribute to proper nerve function, digestion, endurance, and blood formation, as well as vitamin H, or biotin, which is responsible for healthy skin, hair, and nails. Vitamins whose initial letters are contained in the acronym "DEKA" are fat-soluble. Based on the text, classify the vitamins by filling in the table below.

|  |  |
| --- | --- |
| Vitamins that can be overdosed | Vitamins that cannot be overdosed |
|  |  |

**Teacher notes for Student sheet 22: How much vitamin C is there in orange juice?**

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

Teachers are kindly asked to encourage their students to do experiments by highlighting the importance of experimentation in science and praising them when they think correctly.

Vitamin C (chemically known as ascorbic acid) is necessary for strengthening bones and teeth, producing collagen, and maintaining a healthy immune system. Its deficiency causes scurvy, which once killed many sailors who did not have access to fresh fruit and vegetables during long voyages. As an antioxidant, vitamin C can also reduce the risk of cancer, high blood pressure, heart disease, and age-related vision loss, as it oxidizes easily, meaning it transfers electrons to free radicals with unpaired electrons. By transferring its own electrons, vitamin C prevents aggressive free radicals from "stealing" electrons from our vital molecules (e.g., DNA, proteins), rendering them inoperable. Free radicals are also produced in our bodies, but their quantity is increased by factors such as UV radiation, smoking, alcohol consumption, drug use, and smog.

Our bodies cannot produce vitamin C. On average, we need to consume approximately 80 mg of vitamin C per day. The boxes of various brands of orange juice sold in stores indicate how many milligrams of vitamin C are contained in 100 millilitres. Now you will determine whether this statement is true for the orange juice samples on your trays. Ascorbic acid reacts with iodine according to the following equation:



**Complete the text by entering the appropriate words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones!**

During the chemical reaction, the ascorbic acid molecule (i.e., vitamin C) **donates/accepts electrons**, thus it **is** **oxidized/reduced**, i.e., acting as an **oxidizing agent/reducing agent**.

MATERIALS AND EQUIPMENT: 1% starch solution; Lugol's solution; 2 Pasteur pipettes (marked "S" and "L") or dropper bottles marked "S" and "L" for the starch solution and Lugol's solution, respectively; 2 x 100 cm3 beakers marked "S" and "L" for the starch solution and Lugol's solution, respectively; 50 cm3 of distilled water in a

100 cm3 beaker marked with the number 1; 50 cm3 of distilled water in a 100 cm3 beaker marked with the number 2; half a vitamin C effervescent tablet (80 mg vitamin C/tablet); 50 cm3 of store-bought orange juice in a 100 cm3 beaker marked with the number 3; a wipe or paper towel; a tray; 3 glass rods or spoons; protective gloves and goggles.

**Experiment I.**: There is 50 cm3 of distilled water in beaker No. 1. Add 2 cm3 of starch solution using the Pasteur pipette marked "S", then add 1 drop of Lugol's solution using the Pasteur pipette marked "L."

**Observation**: The solution will turn dark (blue).

**Explanation**: Iodine reacts with starch to produce a blue color. If the solution is more concentrated, the color appears black.

**Experiment II.**: Dissolve half of an effervescent tablet containing 80 mg of vitamin C in 50 cm3 of distilled water in beaker No. 2. Add 2 cm3 of starch solution to the solution using the Pasteur pipette marked "S". Then, using the Pasteur pipette marked "L", add Lugol's solution to the ascorbic acid solution while stirring. Count how many drops of Lugol's solution are needed to achieve the desired color change.

**Observation**: 31 drops of Lugol's solution changed permanently the color of the solution.

**Explanation**: As long as there is ascorbic acid in the solution, it reacts with the iodine content of the Lugol's solution added to it, so the starch does not show the presence of iodine at this point. When the ascorbic acid is depleted, there is nothing left to react with the iodine in the Lugol's solution, so the starch shows the presence of iodine with its remaining dark color.

**Conclusion:** Based on the above, it can be calculated that 1 drop of Lugol's solution reacts with 1.3 mg of ascorbic acid.

**Experiment III.**: The box of store-bought orange juice in beaker No. 3 states that 100 milliliters of the beverage

contains 32 mg of vitamin C. Based on the results of the previous experiments, the following experiment can be used to determine whether the orange juice contains the amount of vitamin C stated on the box.

THE STEPS OF THE EXPERIMENTS:

(1) Add 2 cm3 of starch solution to the orange juice in beaker No. 3 using the Pasteur pipette marked "S".

(2) While stirring, add Lugol's solution to the orange juice using the Pasteur pipette marked "L".

(3) Count how many drops of Lugol's solution are needed to achieve the remaining color change!

1. OBSERVATIONS: 14 drops of Lugol's solution permanently changed the color of the solution.

2. Explanation: In Experiment II., 1 drop of Lugol's solution reacted with 1.3 mg of ascorbic acid.

Therefore, in Experiment III., the iodine in 14 drops of Lugol's solution reacted with approximately

18 mg of ascorbic acid.

3. CONCLUSION: 50 cm3 of orange juice contains 18 mg of ascorbic acid, i.e. vitamin C. Therefore,

100 cm3 of orange juice contains 36 mg of vitamin C. Considering that measurements taken with such simple tools are highly inaccurate, this value is a **fairly good approximation/~~not close~~** to the vitamin C content indicated on the box. (Since vitamin C is unstable, it is also possible that the manufacturer adds more vitamin C to the orange juice so that there are no problems during quality control.)

4. LET'S THINK!

Linus Carl Pauling, who won the Nobel Prize in Chemistry in 1954 for his achievements in researching the nature of chemical bonds, suffered from what is known as "Nobel Prize disease." This is the name given to the phenomenon whereby scientists who have made genuine scientific breakthroughs imagine that they are also experts in fields of science in which they have no expertise. Pauling, for example, recommended the use of megadoses of vitamin C (i.e. 3000 mg per day), but the positive effects of this have not been confirmed by medical research since then. Fortunately for those who follow Pauling's advice, vitamin C is water-soluble, so any excess is excreted from the body in urine, although it does increase the risk of kidney stones. Water-soluble vitamins also include B vitamins, which contribute to proper nerve function, digestion, endurance, and blood formation, as well as vitamin H, or biotin, which is responsible for healthy skin, hair, and nails. Vitamins whose initial letters are contained in the acronym "DEKA" are fat-soluble. Based on the text, classify the vitamins by filling in the table below.

|  |  |
| --- | --- |
| Vitamins that can be overdosed | Vitamins that cannot be overdosed |
| A, D, E, K | B, C, H |

**Student sheet 22: How much vitamin C is there in orange juice?**

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

Vitamin C (chemically known as ascorbic acid) is necessary for strengthening bones and teeth, producing collagen, and maintaining a healthy immune system. Its deficiency causes scurvy, which once killed many sailors who did not have access to fresh fruit and vegetables during long voyages. As an antioxidant, vitamin C can also reduce the risk of cancer, high blood pressure, heart disease, and age-related vision loss, as it oxidizes easily, meaning it transfers electrons to free radicals with unpaired electrons. By transferring its own electrons, vitamin C prevents aggressive free radicals from "stealing" electrons from our vital molecules (e.g., DNA, proteins), rendering them inoperable. Free radicals are also produced in our bodies, but their quantity is increased by factors such as UV radiation, smoking, alcohol consumption, drug use, and smog.

Our bodies cannot produce vitamin C. On average, we need to consume approximately 80 mg of vitamin C per day. The boxes of various brands of orange juice sold in stores indicate how many milligrams of vitamin C are contained in 100 millilitres. Now you will determine whether this statement is true for the orange juice samples on your trays. Ascorbic acid reacts with iodine according to the following equation:



**Complete the text by entering the appropriate words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones!**

During the chemical reaction, the ascorbic acid molecule (i.e., vitamin C) **donates/accepts electrons**, thus it **is** **oxidized/reduced**, i.e., acting as an **oxidizing agent/reducing agent**.

MATERIALS AND EQUIPMENT: 1% starch solution; Lugol's solution; 2 Pasteur pipettes (marked "S" and "L") or dropper bottles marked "S" and "L" for the starch solution and Lugol's solution, respectively; 2 x 100 cm3 beakers marked "S" and "L" for the starch solution and Lugol's solution, respectively; 50 cm3 of distilled water in a

100 cm3 beaker marked with the number 1; 50 cm3 of distilled water in a 100 cm3 beaker marked with the number 2; half a vitamin C effervescent tablet (80 mg vitamin C/tablet); 50 cm3 of store-bought orange juice in a 100 cm3 beaker marked with the number 3; a wipe or paper towel; a tray; 3 glass rods or spoons; protective gloves and goggles.

**Experiment I.**: There is 50 cm3 of distilled water in beaker No. 1. Add 2 cm3 of starch solution using the Pasteur pipette marked "S", then add 1 drop of Lugol's solution using the Pasteur pipette marked "L."

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

**Explanation**: Iodine reacts with starch to produce a ………………………...… color. If the solution is more concentrated, the color appears black.

**Experiment II.**: Dissolve half of an effervescent tablet containing 80 mg of vitamin C in 50 cm3 of distilled water in beaker No. 2. Add 2 cm3 of starch solution to the solution using the Pasteur pipette marked "S". Then, using the Pasteur pipette marked "L", add Lugol's solution to the ascorbic acid solution while stirring. Count how many drops of Lugol's solution are needed to achieve the desired color change.

**Observation**: ………………… drops of Lugol's solution changed permanently the color of the solution.

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

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

**Conclusion:** Based on the above, it can be calculated that 1 drop of Lugol's solution reacts with ……………….. mg of ascorbic acid.

**Experiment III.**: The box of store-bought orange juice in beaker No. 3 states that 100 milliliters of the beverage

contains …….. mg of vitamin C. Based on the results of the previous experiments, the following experiment can be used to determine whether the orange juice contains the amount of vitamin C stated on the box.

THE STEPS OF THE EXPERIMENTS:

(1) Add 2 cm3 of starch solution to the orange juice in beaker No. 3 using the Pasteur pipette marked "S".

(2) While stirring, add Lugol's solution to the orange juice using the Pasteur pipette marked "L".

(3) Count how many drops of Lugol's solution are needed to achieve the remaining color change!

1. OBSERVATIONS: ……………….. drops of Lugol's solution permanently changed the color of the solution.

2. Explanation: In Experiment II., 1 drop of Lugol's solution reacted with ……………….. mg of ascorbic acid.

Therefore, in Experiment III., the iodine in ……………….. drops of Lugol's solution reacted with approximately

……………….. mg of ascorbic acid.

3. CONCLUSION: 50 cm3 of orange juice contains …………………….….. mg of ascorbic acid, i.e. vitamin C. Therefore,

100 cm3 of orange juice contains ……………….. mg of vitamin C. Considering that measurements taken with such simple tools are highly inaccurate, this value is a **fairly good approximation/not close** to the vitamin C content indicated on the box. (Since vitamin C is unstable, it is also possible that the manufacturer adds more vitamin C to the orange juice so that there are no problems during quality control.)

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

4. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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

5. WHAT WAS THE DEPENDENT VARIABLE?

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

6. HOW COULD YOU TEST THIS DEPENDENT VARIABLE? ……………………………………………………………………………………….

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

7. THIS WAS THE ASSUMPTION (HYPOTHESIS:

If ……………………………………………………………………..………………………………………………………………………. (the independent

variable changes as intended), then ………………………………………………………………………………………. (the dependent variable will change in this way).

8. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X** sign!

The volume of Lugol's solution added.  The volume of the solution containing vitamin C.

The concentration of Lugol's solution.  Concentration of vitamin C solution.

The concentration of the starch solution.  The volume of the starch solution.

9. LET'S THINK!

Linus Carl Pauling, who won the Nobel Prize in Chemistry in 1954 for his achievements in researching the nature of chemical bonds, suffered from what is known as "Nobel Prize disease." This is the name given to the phenomenon whereby scientists who have made genuine scientific breakthroughs imagine that they are also experts in fields of science in which they have no expertise. Pauling, for example, recommended the use of megadoses of vitamin C (i.e. 3000 mg per day), but the positive effects of this have not been confirmed by medical research since then. Fortunately for those who follow Pauling's advice, vitamin C is water-soluble, so any excess is excreted from the body in urine, although it does increase the risk of kidney stones. Water-soluble vitamins also include B vitamins, which contribute to proper nerve function, digestion, endurance, and blood formation, as well as vitamin H, or biotin, which is responsible for healthy skin, hair, and nails. Vitamins whose initial letters are contained in the acronym "DEKA" are fat-soluble. Based on the text, classify the vitamins by filling in the table below.

|  |  |
| --- | --- |
| Vitamins that can be overdosed | Vitamins that cannot be overdosed |
|  |  |

**Teacher notes for Student sheet 22: How much vitamin C is there in orange juice?**

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

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

Vitamin C (chemically known as ascorbic acid) is necessary for strengthening bones and teeth, producing collagen, and maintaining a healthy immune system. Its deficiency causes scurvy, which once killed many sailors who did not have access to fresh fruit and vegetables during long voyages. As an antioxidant, vitamin C can also reduce the risk of cancer, high blood pressure, heart disease, and age-related vision loss, as it oxidizes easily, meaning it transfers electrons to free radicals with unpaired electrons. By transferring its own electrons, vitamin C prevents aggressive free radicals from "stealing" electrons from our vital molecules (e.g., DNA, proteins), rendering them inoperable. Free radicals are also produced in our bodies, but their quantity is increased by factors such as UV radiation, smoking, alcohol consumption, drug use, and smog.

Our bodies cannot produce vitamin C. On average, we need to consume approximately 80 mg of vitamin C per day. The boxes of various brands of orange juice sold in stores indicate how many milligrams of vitamin C are contained in 100 millilitres. Now you will determine whether this statement is true for the orange juice samples on your trays. Ascorbic acid reacts with iodine according to the following equation:



**Complete the text by entering the appropriate words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones!**

During the chemical reaction, the ascorbic acid molecule (i.e., vitamin C) **donates/accepts electrons**, thus it **is** **oxidized/reduced**, i.e., acting as an **oxidizing agent/reducing agent**.

MATERIALS AND EQUIPMENT: 1% starch solution; Lugol's solution; 2 Pasteur pipettes (marked "S" and "L") or dropper bottles marked "S" and "L" for the starch solution and Lugol's solution, respectively; 2 x 100 cm3 beakers marked "S" and "L" for the starch solution and Lugol's solution, respectively; 50 cm3 of distilled water in a

100 cm3 beaker marked with the number 1; 50 cm3 of distilled water in a 100 cm3 beaker marked with the number 2; half a vitamin C effervescent tablet (80 mg vitamin C/tablet); 50 cm3 of store-bought orange juice in a 100 cm3 beaker marked with the number 3; a wipe or paper towel; a tray; 3 glass rods or spoons; protective gloves and goggles.

**Experiment I.**: There is 50 cm3 of distilled water in beaker No. 1. Add 2 cm3 of starch solution using the Pasteur pipette marked "S", then add 1 drop of Lugol's solution using the Pasteur pipette marked "L."

**Observation**: The solution will turn dark (blue).

**Explanation**: Iodine reacts with starch to produce a blue color. If the solution is more concentrated, the color appears black.

**Experiment II.**: Dissolve half of an effervescent tablet containing 80 mg of vitamin C in 50 cm3 of distilled water in beaker No. 2. Add 2 cm3 of starch solution to the solution using the Pasteur pipette marked "S". Then, using the Pasteur pipette marked "L", add Lugol's solution to the ascorbic acid solution while stirring. Count how many drops of Lugol's solution are needed to achieve the desired color change.

**Observation**: 31 drops of Lugol's solution changed permanently the color of the solution.

**Explanation**: As long as there is ascorbic acid in the solution, it reacts with the iodine content of the Lugol's solution added to it, so the starch does not show the presence of iodine at this point. When the ascorbic acid is depleted, there is nothing left to react with the iodine in the Lugol's solution, so the starch shows the presence of iodine with its remaining dark color.

**Conclusion:** Based on the above, it can be calculated that 1 drop of Lugol's solution reacts with 1.3 mg of ascorbic acid.

**Experiment III.**: The box of store-bought orange juice in beaker No. 3 states that 100 milliliters of the beverage

contains 32 mg of vitamin C. Based on the results of the previous experiments, the following experiment can be used to determine whether the orange juice contains the amount of vitamin C stated on the box.

THE STEPS OF THE EXPERIMENTS:

(1) Add 2 cm3 of starch solution to the orange juice in beaker No. 3 using the Pasteur pipette marked "S".

(2) While stirring, add Lugol's solution to the orange juice using the Pasteur pipette marked "L".

(3) Count how many drops of Lugol's solution are needed to achieve the remaining color change!

1. OBSERVATIONS: 14 drops of Lugol's solution permanently changed the color of the solution.

2. Explanation: In Experiment II., 1 drop of Lugol's solution reacted with 1.3 mg of ascorbic acid.

Therefore, in Experiment III., the iodine in 14 drops of Lugol's solution reacted with approximately

18 mg of ascorbic acid.

3. CONCLUSION: 50 cm3 of orange juice contains 18 mg of ascorbic acid, i.e. vitamin C. Therefore,

100 cm3 of orange juice contains 36 mg of vitamin C. Considering that measurements taken with such simple tools are highly inaccurate, this value is a **fairly good approximation/~~not close~~** to the vitamin C content indicated on the box. (Since vitamin C is unstable, it is also possible that the manufacturer adds more vitamin C to the orange juice so that there are no problems during quality control.)

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

4. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

The vitamin C content of liquids.

5. WHAT WAS THE DEPENDENT VARIABLE?

The amount of iodine reacting with vitamin C.

6. HOW COULD YOU TEST THIS DEPENDENT VARIABLE?

By counting the drops of Lugol's solution needed to achieve the desired dark color.

7. THIS WAS THE ASSUMPTION (HYPOTHESIS:

If the vitamin C content of orange juice is 32 mg/100 ml (the independent variable changes as intended), then an appropriate amount of iodine reacts with it (the dependent variable will change in this way).

8. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X** sign!

The volume of Lugol's solution added.  The volume of the solution containing vitamin C.

The concentration of Lugol's solution.  Concentration of vitamin C solution.

The concentration of the starch solution.  The volume of the starch solution.

9. LET'S THINK!

Linus Carl Pauling, who won the Nobel Prize in Chemistry in 1954 for his achievements in researching the nature of chemical bonds, suffered from what is known as "Nobel Prize disease." This is the name given to the phenomenon whereby scientists who have made genuine scientific breakthroughs imagine that they are also experts in fields of science in which they have no expertise. Pauling, for example, recommended the use of megadoses of vitamin C (i.e. 3000 mg per day), but the positive effects of this have not been confirmed by medical research since then. Fortunately for those who follow Pauling's advice, vitamin C is water-soluble, so any excess is excreted from the body in urine, although it does increase the risk of kidney stones. Water-soluble vitamins also include B vitamins, which contribute to proper nerve function, digestion, endurance, and blood formation, as well as vitamin H, or biotin, which is responsible for healthy skin, hair, and nails. Vitamins whose initial letters are contained in the acronym "DEKA" are fat-soluble. Based on the text, classify the vitamins by filling in the table below.

|  |  |
| --- | --- |
| Vitamins that can be overdosed | Vitamins that cannot be overdosed |
| A, D, E, K | B, C, H |

**Student sheet 22: How much vitamin C is there in orange juice?**

(type 3: experimental design following a scheme version for Group 3 students)

Vitamin C (chemically known as ascorbic acid) is necessary for strengthening bones and teeth, producing collagen, and maintaining a healthy immune system. Its deficiency causes scurvy, which once killed many sailors who did not have access to fresh fruit and vegetables during long voyages. As an antioxidant, vitamin C can also reduce the risk of cancer, high blood pressure, heart disease, and age-related vision loss, as it oxidizes easily, meaning it transfers electrons to free radicals with unpaired electrons. By transferring its own electrons, vitamin C prevents aggressive free radicals from "stealing" electrons from our vital molecules (e.g., DNA, proteins), rendering them inoperable. Free radicals are also produced in our bodies, but their quantity is increased by factors such as UV radiation, smoking, alcohol consumption, drug use, and smog.

Our bodies cannot produce vitamin C. On average, we need to consume approximately 80 mg of vitamin C per day. The boxes of various brands of orange juice sold in stores indicate how many milligrams of vitamin C are contained in 100 millilitres. Now you will determine whether this statement is true for the orange juice samples on your trays. Ascorbic acid reacts with iodine according to the following equation:



**Complete the text by entering the appropriate words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones!**

During the chemical reaction, the ascorbic acid molecule (i.e., vitamin C) **donates/accepts electrons**, thus it **is** **oxidized/reduced**, i.e., acting as an **oxidizing agent/reducing agent**.

MATERIALS AND EQUIPMENT: 1% starch solution; Lugol's solution; 2 Pasteur pipettes (marked "S" and "L") or dropper bottles marked "S" and "L" for the starch solution and Lugol's solution, respectively; 2 x 100 cm3 beakers marked "S" and "L" for the starch solution and Lugol's solution, respectively; 50 cm3 of distilled water in a

100 cm3 beaker marked with the number 1; 50 cm3 of distilled water in a 100 cm3 beaker marked with the number 2; half a vitamin C effervescent tablet (80 mg vitamin C/tablet); 50 cm3 of store-bought orange juice in a 100 cm3 beaker marked with the number 3; a wipe or paper towel; a tray; 3 glass rods or spoons; protective gloves and goggles.

**Experiment I.**: There is 50 cm3 of distilled water in beaker No. 1. Add 2 cm3 of starch solution using the Pasteur pipette marked "S", then add 1 drop of Lugol's solution using the Pasteur pipette marked "L."

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

**Explanation**: Iodine reacts with starch to produce a ………………………...… color. If the solution is more concentrated, the color appears black.

**Experiment II.**: Dissolve half of an effervescent tablet containing 80 mg of vitamin C in 50 cm3 of distilled water in beaker No. 2. Add 2 cm3 of starch solution to the solution using the Pasteur pipette marked "S". Then, using the Pasteur pipette marked "L", add Lugol's solution to the ascorbic acid solution while stirring. Count how many drops of Lugol's solution are needed to achieve the desired color change.

**Observation**: ………………… drops of Lugol's solution changed permanently the color of the solution.

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

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

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

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

**Conclusion:** Based on the above, it can be calculated that 1 drop of Lugol's solution reacts with ……………….. mg of ascorbic acid.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

**Experiment III.**: The box of store-bought orange juice in beaker No. 3 states that 100 milliliters of the beverage

contains …….. mg of vitamin C. Based on the results of the previous experiments, the following experiment can be used to determine whether the orange juice contains the amount of vitamin C stated on the box.

1. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAVE TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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

2. WHAT IS THE DEPENDENT VARIABLE?

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

3. HOW CAN YOU TEST THIS DEPENDENT VARIABLE? ……………………………………………………………………………………….

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

4. THIS IS THE ASSUMPTION (HYPOTHESIS:

If ……………………………………………………………………..………………………………………………………………………. (the independent

variable changes as intended), then ………………………………………………………………………………………. (the dependent variable will change in this way).

5. HOW CAN INDEPENDENT VARIABLES CHANGE? Plan Experiment III.!

|  |  |
| --- | --- |
| Experiment II. (control experiment): | Experiment III.: |
| number of repetitions in class: | number of repetitions in class: |

6. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X** sign!

The volume of Lugol's solution added.  The volume of the solution containing vitamin C.

The concentration of Lugol's solution.  Concentration of vitamin C solution.

The concentration of the starch solution.  The volume of the starch solution.

7. THE STEPS OF THE EXPERIMENTS:

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

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

……………………………………………………………………………………………………………………………………………………………………………

**After completing the experiments, write down your observations and explanations. Draw conclusions as well!**

8. OBSERVATIONS: ……………………………………………………………………………………………………………………………………………….

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

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

10. CONCLUSION: ………………………………………………………………………………………………………………………………………..………

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

11. LET'S THINK!

Linus Carl Pauling, who won the Nobel Prize in Chemistry in 1954 for his achievements in researching the nature of chemical bonds, suffered from what is known as "Nobel Prize disease." This is the name given to the phenomenon whereby scientists who have made genuine scientific breakthroughs imagine that they are also experts in fields of science in which they have no expertise. Pauling, for example, recommended the use of megadoses of vitamin C (i.e. 3000 mg per day), but the positive effects of this have not been confirmed by medical research since then. Fortunately for those who follow Pauling's advice, vitamin C is water-soluble, so any excess is excreted from the body in urine, although it does increase the risk of kidney stones. Water-soluble vitamins also include B vitamins, which contribute to proper nerve function, digestion, endurance, and blood formation, as well as vitamin H, or biotin, which is responsible for healthy skin, hair, and nails. Vitamins whose initial letters are contained in the acronym "DEKA" are fat-soluble. Based on the text, classify the vitamins by filling in the table below.

|  |  |
| --- | --- |
| Vitamins that can be overdosed | Vitamins that cannot be overdosed |
|  |  |

**Teacher notes for Student sheet 22: How much vitamin C is there in orange juice?**

(type 3: experimental design following a scheme version for Group 3 students)

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

Vitamin C (chemically known as ascorbic acid) is necessary for strengthening bones and teeth, producing collagen, and maintaining a healthy immune system. Its deficiency causes scurvy, which once killed many sailors who did not have access to fresh fruit and vegetables during long voyages. As an antioxidant, vitamin C can also reduce the risk of cancer, high blood pressure, heart disease, and age-related vision loss, as it oxidizes easily, meaning it transfers electrons to free radicals with unpaired electrons. By transferring its own electrons, vitamin C prevents aggressive free radicals from "stealing" electrons from our vital molecules (e.g., DNA, proteins), rendering them inoperable. Free radicals are also produced in our bodies, but their quantity is increased by factors such as UV radiation, smoking, alcohol consumption, drug use, and smog.

Our bodies cannot produce vitamin C. On average, we need to consume approximately 80 mg of vitamin C per day. The boxes of various brands of orange juice sold in stores indicate how many milligrams of vitamin C are contained in 100 millilitres. Now you will determine whether this statement is true for the orange juice samples on your trays. Ascorbic acid reacts with iodine according to the following equation:



**Complete the text by entering the appropriate words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones!**

During the chemical reaction, the ascorbic acid molecule (i.e., vitamin C) **donates/accepts electrons**, thus it **is** **oxidized/reduced**, i.e., acting as an **oxidizing agent/reducing agent**.

MATERIALS AND EQUIPMENT: 1% starch solution; Lugol's solution; 2 Pasteur pipettes (marked "S" and "L") or dropper bottles marked "S" and "L" for the starch solution and Lugol's solution, respectively; 2 x 100 cm3 beakers marked "S" and "L" for the starch solution and Lugol's solution, respectively; 50 cm3 of distilled water in a

100 cm3 beaker marked with the number 1; 50 cm3 of distilled water in a 100 cm3 beaker marked with the number 2; half a vitamin C effervescent tablet (80 mg vitamin C/tablet); 50 cm3 of store-bought orange juice in a 100 cm3 beaker marked with the number 3; a wipe or paper towel; a tray; 3 glass rods or spoons; protective gloves and goggles.

**Experiment I.**: There is 50 cm3 of distilled water in beaker No. 1. Add 2 cm3 of starch solution using the Pasteur pipette marked "S", then add 1 drop of Lugol's solution using the Pasteur pipette marked "L."

**Observation**: The solution will turn dark (blue).

**Explanation**: Iodine reacts with starch to produce a blue color. If the solution is more concentrated, the color appears black.

**Experiment II.**: Dissolve half of an effervescent tablet containing 80 mg of vitamin C in 50 cm3 of distilled water in beaker No. 2. Add 2 cm3 of starch solution to the solution using the Pasteur pipette marked "S". Then, using the Pasteur pipette marked "L", add Lugol's solution to the ascorbic acid solution while stirring. Count how many drops of Lugol's solution are needed to achieve the desired color change.

**Observation**: 31 drops of Lugol's solution changed permanently the color of the solution.

**Explanation**: As long as there is ascorbic acid in the solution, it reacts with the iodine content of the Lugol's solution added to it, so the starch does not show the presence of iodine at this point. When the ascorbic acid is depleted, there is nothing left to react with the iodine in the Lugol's solution, so the starch shows the presence of iodine with its remaining dark color.

**Conclusion:** Based on the above, it can be calculated that 1 drop of Lugol's solution reacts with 1.3 mg of ascorbic acid.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

**Experiment III.**: The box of store-bought orange juice in beaker No. 3 states that 100 milliliters of the beverage

contains 32 mg of vitamin C. Based on the results of the previous experiments, the following experiment can be used to determine whether the orange juice contains the amount of vitamin C stated on the box.

1. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAVE TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

The vitamin C content of liquids.

2. WHAT IS THE DEPENDENT VARIABLE?

The amount of iodine reacting with vitamin C.

3. HOW CAN YOU TEST THIS DEPENDENT VARIABLE? ……………………………………………………………………………………….

By counting the drops of Lugol's solution needed to achieve the desired dark color.

4. THIS IS THE ASSUMPTION (HYPOTHESIS:

If the vitamin C content of orange juice is 32 mg/100 ml (the independent variable changes as intended), then an appropriate amount of iodine reacts with it (the dependent variable will change in this way).

5. HOW CAN INDEPENDENT VARIABLES CHANGE? Plan Experiment III.!

|  |  |
| --- | --- |
| Experiment II. (control experiment): 50 cm3 distilled water + half a effervescent tablet + 2 cm2 starch solution + Lugol's solution added drop by drop (until the color remains dark) | Experiment III.: 50 cm3 orange juice + 2 cm2 starch solution + Lugol's solution added drop by drop (until the color remains dark) |
| number of repetitions in class: | number of repetitions in class: |

6. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X** sign!

The volume of Lugol's solution added.  The volume of the solution containing vitamin C.

The concentration of Lugol's solution.  Concentration of vitamin C solution.

The concentration of the starch solution.  The volume of the starch solution.

7. THE STEPS OF THE EXPERIMENTS:

(1) Add 2 cm3 of starch solution to the orange juice in beaker No. 3 using the Pasteur pipette marked "S".

(2) While stirring, add Lugol's solution to the orange juice using the Pasteur pipette marked "L".

(3) Count how many drops of Lugol's solution are needed to achieve the remaining color change!

**After completing the experiments, write down your observations and explanations. Draw conclusions as well!**

8. OBSERVATIONS: 14 drops of Lugol's solution permanently changed the color of the solution.

9. Explanation: In Experiment II., 1 drop of Lugol's solution reacted with 1.3 mg of ascorbic acid. Therefore, in Experiment III., the iodine in 14 drops of Lugol's solution reacted with approximately 18 mg of ascorbic acid.

3. CONCLUSION: 50 cm3 of orange juice contains 18 mg of ascorbic acid, i.e. vitamin C. Therefore, 100 cm3 of orange juice contains 36 mg of vitamin C. Considering that measurements taken with such simple tools are highly inaccurate, this value is a fairly good approximation of the vitamin C content indicated on the box. (Note: Since vitamin C is unstable, it is also possible that the manufacturer adds more vitamin C to the orange juice so that there are no problems during quality control.)

11. LET'S THINK!

Linus Carl Pauling, who won the Nobel Prize in Chemistry in 1954 for his achievements in researching the nature of chemical bonds, suffered from what is known as "Nobel Prize disease." This is the name given to the phenomenon whereby scientists who have made genuine scientific breakthroughs imagine that they are also experts in fields of science in which they have no expertise. Pauling, for example, recommended the use of megadoses of vitamin C (i.e. 3000 mg per day), but the positive effects of this have not been confirmed by medical research since then. Fortunately for those who follow Pauling's advice, vitamin C is water-soluble, so any excess is excreted from the body in urine, although it does increase the risk of kidney stones. Water-soluble vitamins also include B vitamins, which contribute to proper nerve function, digestion, endurance, and blood formation, as well as vitamin H, or biotin, which is responsible for healthy skin, hair, and nails. Vitamins whose initial letters are contained in the acronym "DEKA" are fat-soluble. Based on the text, classify the vitamins by filling in the table below.

|  |  |
| --- | --- |
| Vitamins that can be overdosed | Vitamins that cannot be overdosed |
| A, D, E, K | B, C, H |

END OF THE 22nd STUDENT SHEETS AND TEACHER NOTES

**Student sheet** **23: A 4,000-year success story – aspirin**

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

"*Do you have a cold, a fever, or sore joints? Take an aspirin!" We say this all the time to children and adults alike.[[1]](#footnote-1)* The main active ingredient in aspirin tablets is acetylsalicylic acid, which is an ester of salicylic acid and acetic acid. The Sumerians used another derivative of salicylic acid, found in willow leaves and bark, to relieve pain caused by rheumatic diseases around 4,000 years ago. Around 400 BC, the famous Greek physician Hippocrates recommended that women chew willow leaves to relieve labor pains. Aspirin was developed in 1898 by Felix Hofmann, a chemist at I.G. Farben Bayer. His father took salicylic acid, but it caused him stomach problems, so Hofmann sought a substance that would eliminate this side effect. In 1950, the aspirin tablet entered the Guinness Book of Records as the best-selling painkiller. It was later discovered that it also reduces the risk of heart attack and cerebral thrombosis.

The patient information leaflet for aspirin tablets states: "Do not take this medicine after the expiry date (EXP) printed on the box." Expired aspirin tablets may contain salicylic acid as a decomposition product, which can cause stomach problems. Esters can slowly hydrolyze when exposed to moisture, producing the corresponding alcohol or phenol and carboxylic acid. In this case, acetic acid and salicylic acid can be produced from aspirin:



Salicylic acid, which is used in households to preserve compote and jams, can be easily identified using a chemical experiment.

MATERIALS AND EQUIPMENT: salicylic acid (in the watch glass or soda bottle cap marked 1), usable and expired aspirin tablets (in one of the watch glasses/soda bottle caps marked 2 and 3), iron(III) chloride solution (FeCl3), 1 Pasteur pipette or dropper, rubber gloves, safety goggles, paper towels

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

**Experiment 1:** A white powder, salicylic acid, is found in a watch glass marked 1. Add 3-4 drops of iron(III) chloride solution and observe the change!

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

**Explanation:** Salicylic acid is a …………………………………. type compound containing a phenolic hydroxyl group. Iron(III) chloride solution is a substance suitable for detecting compounds containing phenolic hydroxyl groups.

During the reaction, a …………………………………. colored compound is formed.

**Experiment 2:** The watch glasses numbered 2 and 3 contain an aspirin tablet that has expired and an aspirin tablet that is still usable, in unknown order. Based on the experience of the previous experiment, the following experiment can be used to determine which aspirin tablet is in which watch glass.

STEPS OF THE EXPERIMENT

1. Add 3-4 drops of iron(III) chloride solution to the white powder in the watch glass marked 2.
2. Observe and note the color that develops.
3. Add 3-4 drops of iron(III) chloride solution to the white powder in the watch glass marked 3.
4. Observe and note the color that develops.

1. OBSERVATION:

When the reagent is added to the white powder marked 2., the color ……………………………………………… appears.

When the reagent is added to the white powder marked 3., the color ……………………………………………… appears.

2. Explanation:

During the reaction of iron(III) ions with compounds containing phenolic hydroxyl groups, a characteristic

…………………….. color is visible. Phenolic hydroxyl groups are found in **salicylic acid/aspirin tablets**, while **salicylic acid/aspirin tablets** do not contain such functional groups.

3. CONCLUSION:

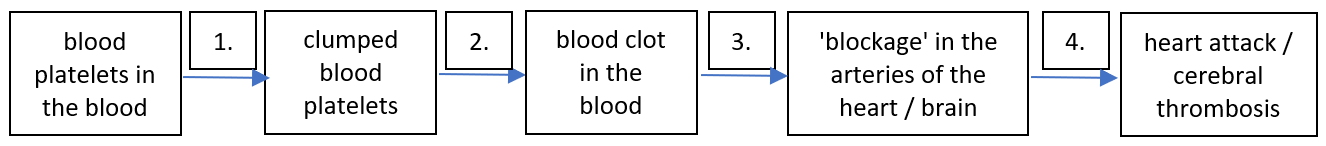
The white powder marked ………… is an expired aspirin tablet, as salicylic acid can be detected in it.

The white powder marked ………… is a usable aspirin tablet, as no salicylic acid was detected in it.

4. LET’S THINK!

"*Acetylsalicylic acid... inhibits platelet aggregation (clumping) in the blood, making it ideal for preventing cardiovascular thrombotic diseases.*"[[2]](#footnote-2) Based on the above quote, how does aspirin reduce the risk of heart attack and cerebral thrombosis? Of the steps shown in the flowchart below, which is the one that the aspirin tablet

prevents? ……………………..



Mark with an **X** the factors that, to the best of your knowledge, may increase the risk of heart attack and cerebral thrombosis!

☐ High blood sugar levels ☐ High cholesterol levels ☐ High blood pressure

☐ Smoking ☐ Obesity ☐ Regular exercise

**Teacher notes for Student sheet 23: A 4,000-year success story – aspirin**

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

Teachers are kindly asked to encourage their students to do experiments by highlighting the importance of experimentation in science and praising them when they think correctly.

"*Do you have a cold, a fever, or sore joints? Take an aspirin!" We say this all the time to children and adults alike.[[3]](#footnote-3)* The main active ingredient in aspirin tablets is acetylsalicylic acid, which is an ester of salicylic acid and acetic acid. The Sumerians used another derivative of salicylic acid, found in willow leaves and bark, to relieve pain caused by rheumatic diseases around 4,000 years ago. Around 400 BC, the famous Greek physician Hippocrates recommended that women chew willow leaves to relieve labor pains. Aspirin was developed in 1898 by Felix Hofmann, a chemist at I.G. Farben Bayer. His father took salicylic acid, but it caused him stomach problems, so Hofmann sought a substance that would eliminate this side effect. In 1950, the aspirin tablet entered the Guinness Book of Records as the best-selling painkiller. It was later discovered that it also reduces the risk of heart attack and cerebral thrombosis.

The patient information leaflet for aspirin tablets states: "Do not take this medicine after the expiry date (EXP) printed on the box." Expired aspirin tablets may contain salicylic acid as a decomposition product, which can cause stomach problems. Esters can slowly hydrolyze when exposed to moisture, producing the corresponding alcohol or phenol and carboxylic acid. In this case, acetic acid and salicylic acid can be produced from aspirin:



Salicylic acid, which is used in households to preserve compote and jams, can be easily identified using a chemical experiment.

MATERIALS AND EQUIPMENT: salicylic acid (in the watch glass or soda bottle cap marked 1), usable and expired aspirin tablets (in one of the watch glasses/soda bottle caps marked 2 and 3), iron(III) chloride solution (FeCl3), 1 Pasteur pipette or dropper, rubber gloves, safety goggles, paper towels

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

**Experiment 1:** A white powder, salicylic acid, is found in a watch glass marked 1. Add 3-4 drops of iron(III) chloride solution and observe the change!

**Observation:** The yellow color of the iron(III) chloride solution dropped onto the white powder disappears and is replaced by a purple color.

**Explanation:** Salicylic acid is a carbonic acid type compound containing a phenolic hydroxyl group. Iron(III) chloride solution is a substance suitable for detecting compounds containing phenolic hydroxyl groups.

During the reaction, a lilac colored compound is formed.

**Experiment 2:** The watch glasses numbered 2 and 3 contain an aspirin tablet that has expired and an aspirin tablet that is still usable, in unknown order. Based on the experience of the previous experiment, the following experiment can be used to determine which aspirin tablet is in which watch glass.

STEPS OF THE EXPERIMENT

1. Add 3-4 drops of iron(III) chloride solution to the white powder in the watch glass marked 2.
2. Observe and note the color that develops.
3. Add 3-4 drops of iron(III) chloride solution to the white powder in the watch glass marked 3.
4. Observe and note the color that develops.

1. OBSERVATION:

When the reagent is added to the white powder marked 2., the color yellowish brown appears.

When the reagent is added to the white powder marked 3., the color lilac appears.

2. Explanation:

During the reaction of iron(III) ions with compounds containing phenolic hydroxyl groups, a characteristic

lilac color is visible. Phenolic hydroxyl groups are found in **salicylic acid/aspirin tablets**, while **salicylic acid/aspirin tablets** do not contain such functional groups.

3. CONCLUSION:

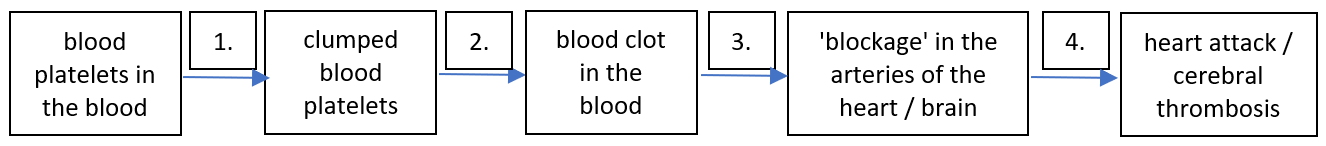
The white powder marked 3. is an expired aspirin tablet, as salicylic acid can be detected in it.

The white powder marked 2. is a usable aspirin tablet, as no salicylic acid was detected in it.

4. LET’S THINK!

"*Acetylsalicylic acid... inhibits platelet aggregation (clumping) in the blood, making it ideal for preventing cardiovascular thrombotic diseases.*"[[4]](#footnote-4) Based on the above quote, how does aspirin reduce the risk of heart attack and cerebral thrombosis? Of the steps shown in the flowchart below, which is the one that the aspirin tablet

prevents? 1.



Mark with an **X** the factors that, to the best of your knowledge, may increase the risk of heart attack and cerebral thrombosis!

High blood sugar levels  High cholesterol levels  High blood pressure

Smoking  Obesity ☐ Regular exercise

**Student sheet 23: A 4,000-year success story – aspirin**

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

"*Do you have a cold, a fever, or sore joints? Take an aspirin!" We say this all the time to children and adults alike.[[5]](#footnote-5)* The main active ingredient in aspirin tablets is acetylsalicylic acid, which is an ester of salicylic acid and acetic acid. The Sumerians used another derivative of salicylic acid, found in willow leaves and bark, to relieve pain caused by rheumatic diseases around 4,000 years ago. Around 400 BC, the famous Greek physician Hippocrates recommended that women chew willow leaves to relieve labor pains. Aspirin was developed in 1898 by Felix Hofmann, a chemist at I.G. Farben Bayer. His father took salicylic acid, but it caused him stomach problems, so Hofmann sought a substance that would eliminate this side effect. In 1950, the aspirin tablet entered the Guinness Book of Records as the best-selling painkiller. It was later discovered that it also reduces the risk of heart attack and cerebral thrombosis.

The patient information leaflet for aspirin tablets states: "Do not take this medicine after the expiry date (EXP) printed on the box." Expired aspirin tablets may contain salicylic acid as a decomposition product, which can cause stomach problems. Esters can slowly hydrolyze when exposed to moisture, producing the corresponding alcohol or phenol and carboxylic acid. In this case, acetic acid and salicylic acid can be produced from aspirin:



Salicylic acid, which is used in households to preserve compote and jams, can be easily identified using a chemical experiment.

MATERIALS AND EQUIPMENT: salicylic acid (in the watch glass or soda bottle cap marked 1), usable and expired aspirin tablets (in one of the watch glasses/soda bottle caps marked 2 and 3), iron(III) chloride solution (FeCl3), 1 Pasteur pipette or dropper, rubber gloves, safety goggles, paper towels

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

**Experiment 1:** A white powder, salicylic acid, is found in a watch glass marked 1. Add 3-4 drops of iron(III) chloride solution and observe the change!

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

**Explanation:** Salicylic acid is a …………………………………. type compound containing a phenolic hydroxyl group. Iron(III) chloride solution is a substance suitable for detecting compounds containing phenolic hydroxyl groups.

During the reaction, a …………………………………. colored compound is formed.

**Experiment 2:** The watch glasses numbered 2 and 3 contain an aspirin tablet that has expired and an aspirin tablet that is still usable, in unknown order. Based on the experience of the previous experiment, the following experiment can be used to determine which aspirin tablet is in which watch glass.

STEPS OF THE EXPERIMENT

1. Add 3-4 drops of iron(III) chloride solution to the white powder in the watch glass marked 2.
2. Observe and note the color that develops.
3. Add 3-4 drops of iron(III) chloride solution to the white powder in the watch glass marked 3.
4. Observe and note the color that develops.

1. OBSERVATION:

When the reagent is added to the white powder marked 2., the color ……………………………………………… appears.

When the reagent is added to the white powder marked 3., the color ……………………………………………… appears.

2. Explanation:

During the reaction of iron(III) ions with compounds containing phenolic hydroxyl groups, a characteristic

…………………….. color is visible. Phenolic hydroxyl groups are found in **salicylic acid/aspirin tablets**, while **salicylic acid/aspirin tablets** do not contain such functional groups.

3. CONCLUSION:

The white powder marked ………… is an expired aspirin tablet, as salicylic acid can be detected in it.

The white powder marked ………… is a usable aspirin tablet, as no salicylic acid was detected in it.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

4. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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

5. WHAT WAS THE DEPENDENT VARIABLE?

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

6. HOW COULD YOU TEST THIS DEPENDENT VARIABLE? ……………………………………………………………………………………….

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

7. THIS WAS THE ASSUMPTION (HYPOTHESIS:

If ……………………………………………………………………..………………………………………………………………………. (the independent

variable changes as intended), then ………………………………………………………………………………………. (the dependent variable will change in this way).

8. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X** sign!

The surface area of the watch glass or soda bottle cap.

The amount of salicylic acid and unknown white substances.

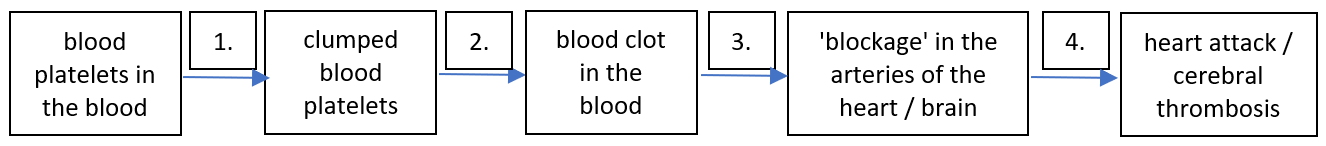
The volume of the iron(III) chloride solution.  The time elapsed after adding the reagent.

The concentration of the iron(III) chloride solution.

9. LET'S THINK!

"*Acetylsalicylic acid... inhibits platelet aggregation (clumping) in the blood, making it ideal for preventing cardiovascular thrombotic diseases.*"[[6]](#footnote-6) Based on the above quote, how does aspirin reduce the risk of heart attack and cerebral thrombosis? Of the steps shown in the flowchart below, which is the one that the aspirin tablet

prevents? ……………………..



Mark with an **X** the factors that, to the best of your knowledge, may increase the risk of heart attack and cerebral thrombosis!

☐ High blood sugar levels ☐ High cholesterol levels ☐ High blood pressure

☐ Smoking ☐ Obesity ☐ Regular exercise

**Teacher notes for Student sheet 23: A 4,000-year success story – aspirin**

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

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

"*Do you have a cold, a fever, or sore joints? Take an aspirin!" We say this all the time to children and adults alike.[[7]](#footnote-7)* The main active ingredient in aspirin tablets is acetylsalicylic acid, which is an ester of salicylic acid and acetic acid. The Sumerians used another derivative of salicylic acid, found in willow leaves and bark, to relieve pain caused by rheumatic diseases around 4,000 years ago. Around 400 BC, the famous Greek physician Hippocrates recommended that women chew willow leaves to relieve labor pains. Aspirin was developed in 1898 by Felix Hofmann, a chemist at I.G. Farben Bayer. His father took salicylic acid, but it caused him stomach problems, so Hofmann sought a substance that would eliminate this side effect. In 1950, the aspirin tablet entered the Guinness Book of Records as the best-selling painkiller. It was later discovered that it also reduces the risk of heart attack and cerebral thrombosis.

The patient information leaflet for aspirin tablets states: "Do not take this medicine after the expiry date (EXP) printed on the box." Expired aspirin tablets may contain salicylic acid as a decomposition product, which can cause stomach problems. Esters can slowly hydrolyze when exposed to moisture, producing the corresponding alcohol or phenol and carboxylic acid. In this case, acetic acid and salicylic acid can be produced from aspirin:



Salicylic acid, which is used in households to preserve compote and jams, can be easily identified using a chemical experiment.

MATERIALS AND EQUIPMENT: salicylic acid (in the watch glass or soda bottle cap marked 1), usable and expired aspirin tablets (in one of the watch glasses/soda bottle caps marked 2 and 3), iron(III) chloride solution (FeCl3), 1 Pasteur pipette or dropper, rubber gloves, safety goggles, paper towels

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

**Experiment 1:** A white powder, salicylic acid, is found in a watch glass marked 1. Add 3-4 drops of iron(III) chloride solution and observe the change!

**Observation:** The yellow color of the iron(III) chloride solution dropped onto the white powder disappears and is replaced by a purple color.

**Explanation:** Salicylic acid is a carbonic acid type compound containing a phenolic hydroxyl group. Iron(III) chloride solution is a substance suitable for detecting compounds containing phenolic hydroxyl groups.

During the reaction, a lilac colored compound is formed.

**Experiment 2:** The watch glasses numbered 2 and 3 contain an aspirin tablet that has expired and an aspirin tablet that is still usable, in unknown order. Based on the experience of the previous experiment, the following experiment can be used to determine which aspirin tablet is in which watch glass.

STEPS OF THE EXPERIMENT

1. Add 3-4 drops of iron(III) chloride solution to the white powder in the watch glass marked 2.
2. Observe and note the color that develops.
3. Add 3-4 drops of iron(III) chloride solution to the white powder in the watch glass marked 3.
4. Observe and note the color that develops.

1. OBSERVATION:

When the reagent is added to the white powder marked 2., the color yellowish brown appears.

When the reagent is added to the white powder marked 3., the color lilac appears.

2. Explanation:

During the reaction of iron(III) ions with compounds containing phenolic hydroxyl groups, a characteristic

lilac color is visible. Phenolic hydroxyl groups are found in **salicylic acid/aspirin tablets**, while **salicylic acid/aspirin tablets** do not contain such functional groups.

3. CONCLUSION:

The white powder marked 3. is an expired aspirin tablet, as salicylic acid can be detected in it.

The white powder marked 2. is a usable aspirin tablet, as no salicylic acid was detected in it.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

4. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

The chemical quality of white powders.

5. WHAT WAS THE DEPENDENT VARIABLE?

Does a chemical reaction occur as a result of the reagent used [iron(III) chloride solution] or not?

6. HOW COULD YOU TEST THIS DEPENDENT VARIABLE? Does the reaction produce the lilac color characteristic of the reaction of the phenolic hydroxyl group with iron(III) chloride solution?

7. THIS WAS THE ASSUMPTION (HYPOTHESIS):

If the reaction is performed with white powder containing salicylic acid (the independent variable changes as intended), then a lilac color will appear during the reaction (the dependent variable will change in this way).

8. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X** sign!

The surface area of the watch glass or soda bottle cap.

The amount of salicylic acid and unknown white substances.

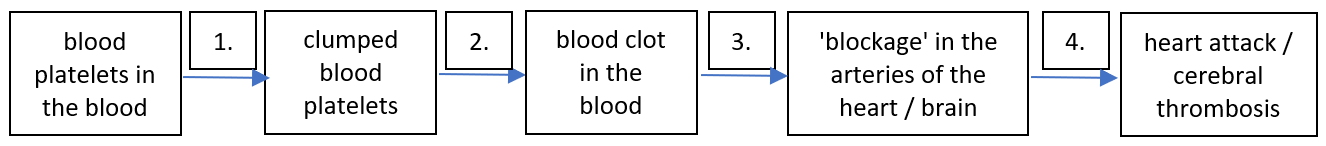
The volume of the iron(III) chloride solution.  The time elapsed after adding the reagent.

The concentration of the iron(III) chloride solution.

9. LET’S THINK!

"*Acetylsalicylic acid... inhibits platelet aggregation (clumping) in the blood, making it ideal for preventing cardiovascular thrombotic diseases.*"[[8]](#footnote-8) Based on the above quote, how does aspirin reduce the risk of heart attack and cerebral thrombosis? Of the steps shown in the flowchart below, which is the one that the aspirin tablet

prevents? 1.



Mark with an **X** the factors that, to the best of your knowledge, may increase the risk of heart attack and cerebral thrombosis!

High blood sugar levels  High cholesterol levels  High blood pressure

Smoking  Obesity ☐ Regular exercise

**Student sheet 23: A 4,000-year success story – aspirin**

(type 3: experimental design following a scheme version for Group 3 students)

"*Do you have a cold, a fever, or sore joints? Take an aspirin!" We say this all the time to children and adults alike.[[9]](#footnote-9)* The main active ingredient in aspirin tablets is acetylsalicylic acid, which is an ester of salicylic acid and acetic acid. The Sumerians used another derivative of salicylic acid, found in willow leaves and bark, to relieve pain caused by rheumatic diseases around 4,000 years ago. Around 400 BC, the famous Greek physician Hippocrates recommended that women chew willow leaves to relieve labor pains. Aspirin was developed in 1898 by Felix Hofmann, a chemist at I.G. Farben Bayer. His father took salicylic acid, but it caused him stomach problems, so Hofmann sought a substance that would eliminate this side effect. In 1950, the aspirin tablet entered the Guinness Book of Records as the best-selling painkiller. It was later discovered that it also reduces the risk of heart attack and cerebral thrombosis.

The patient information leaflet for aspirin tablets states: "Do not take this medicine after the expiry date (EXP) printed on the box." Expired aspirin tablets may contain salicylic acid as a decomposition product, which can cause stomach problems. Esters can slowly hydrolyze when exposed to moisture, producing the corresponding alcohol or phenol and carboxylic acid. In this case, acetic acid and salicylic acid can be produced from aspirin:



Salicylic acid, which is used in households to preserve compote and jams, can be easily identified using a chemical experiment.

MATERIALS AND EQUIPMENT: salicylic acid (in the watch glass or soda bottle cap marked 1), usable and expired aspirin tablets (in one of the watch glasses/soda bottle caps marked 2 and 3), iron(III) chloride solution (FeCl3), 1 Pasteur pipette or dropper, rubber gloves, safety goggles, paper towels

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

**Experiment 1:** A white powder, salicylic acid, is found in a watch glass marked 1. Add 3-4 drops of iron(III) chloride solution and observe the change!

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

**Explanation:** Salicylic acid is a …………………………………. type compound containing a phenolic hydroxyl group. Iron(III) chloride solution is a substance suitable for detecting compounds containing phenolic hydroxyl groups.

During the reaction, a …………………………………. colored compound is formed.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

**Experiment II.:** Use Experiment I. as a control experiment and compare its results with those of the following experiment. How could you use the materials and tools available to identify which of the unknown white powders labelled 2. and 3. is expired aspirin and which is still usable?

1. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAVE TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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

2. WHAT IS THE DEPENDENT VARIABLE?

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

3. HOW CAN YOU TEST THIS DEPENDENT VARIABLE? ………………………………………..……………………………………………………….

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

4. THIS IS THE ASSUMPTION (HYPOTHESIS): If ……………………………………………………………………………………………………….

(the independent variable changes as intended), then ………………………………………………………………………………………. (the dependent variable will change in this way).

5. HOW CAN THE INDEPENDENT VARIABLE CHANGE?

|  |  |
| --- | --- |
| Experiment II.a: | Experiment II.b: |
| number of repetitions in class: | number of repetitions in class: |

6. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with a **X** sign!

The surface area of the watch glass or soda bottle cap.

The amount of salicylic acid and unknown white substances.

The volume of the iron(III) chloride solution.  The time elapsed after adding the reagent.

The concentration of the iron(III) chloride solution.

7. THE STEPS OF THE EXPERIMENTS:

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

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

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

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

**After the experiments are done, write down your observations and explanations. Draw a conclusion too.**

8. OBSERVATION:

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

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

9. Explanation:

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

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

10. CONCLUSION:

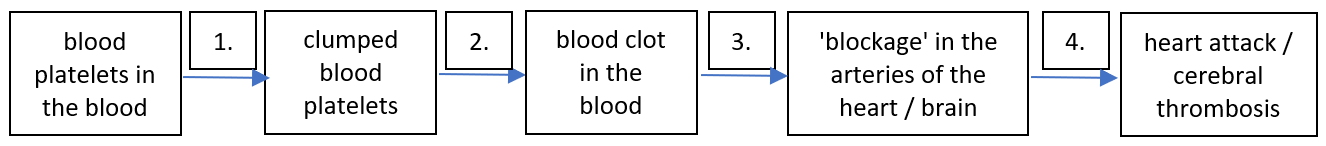
…………………………………………………………………………………………………………………………………………………………………………….

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

11. LET’S THINK!

"*Acetylsalicylic acid... inhibits platelet aggregation (clumping) in the blood, making it ideal for preventing cardiovascular thrombotic diseases.*"[[10]](#footnote-10) Based on the above quote, how does aspirin reduce the risk of heart attack and cerebral thrombosis? Of the steps shown in the flowchart below, which is the one that the aspirin tablet

prevents? ……………………..



Mark with an **X** the factors that, to the best of your knowledge, may increase the risk of heart attack and cerebral thrombosis!

☐ High blood sugar levels ☐ High cholesterol levels ☐ High blood pressure

☐ Smoking ☐ Obesity ☐ Regular exercise

**Teacher notes for Student sheet 23: A 4,000-year success story – aspirin**

(type 3: experimental design following a scheme version for Group 3 students)

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

"*Do you have a cold, a fever, or sore joints? Take an aspirin!" We say this all the time to children and adults alike.[[11]](#footnote-11)* The main active ingredient in aspirin tablets is acetylsalicylic acid, which is an ester of salicylic acid and acetic acid. The Sumerians used another derivative of salicylic acid, found in willow leaves and bark, to relieve pain caused by rheumatic diseases around 4,000 years ago. Around 400 BC, the famous Greek physician Hippocrates recommended that women chew willow leaves to relieve labor pains. Aspirin was developed in 1898 by Felix Hofmann, a chemist at I.G. Farben Bayer. His father took salicylic acid, but it caused him stomach problems, so Hofmann sought a substance that would eliminate this side effect. In 1950, the aspirin tablet entered the Guinness Book of Records as the best-selling painkiller. It was later discovered that it also reduces the risk of heart attack and cerebral thrombosis.

The patient information leaflet for aspirin tablets states: "Do not take this medicine after the expiry date (EXP) printed on the box." Expired aspirin tablets may contain salicylic acid as a decomposition product, which can cause stomach problems. Esters can slowly hydrolyze when exposed to moisture, producing the corresponding alcohol or phenol and carboxylic acid. In this case, acetic acid and salicylic acid can be produced from aspirin:



Salicylic acid, which is used in households to preserve compote and jams, can be easily identified using a chemical experiment.

MATERIALS AND EQUIPMENT: salicylic acid (in the watch glass or soda bottle cap marked 1), usable and expired aspirin tablets (in one of the watch glasses/soda bottle caps marked 2 and 3), iron(III) chloride solution (FeCl3), 1 Pasteur pipette or dropper, rubber gloves, safety goggles, paper towels

**Complete the text by entering the appropriate** **words, underlining or framing the correct words, or ~~crossing out~~ the incorrect ones.**

**Experiment 1:** A white powder, salicylic acid, is found in a watch glass marked 1. Add 3-4 drops of iron(III) chloride solution and observe the change!

**Observation:** The yellow color of the iron(III) chloride solution dropped onto the white powder disappears and is replaced by a purple color.

**Explanation:** Salicylic acid is a carbonic acid type compound containing a phenolic hydroxyl group. Iron(III) chloride solution is a substance suitable for detecting compounds containing phenolic hydroxyl groups.

During the reaction, a lilac colored compound is formed.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

**Experiment II.:** Use Experiment I. as a control experiment and compare its results with those of the following experiment. How could you use the materials and tools available to identify which of the unknown white powders labelled 2. and 3. is expired aspirin and which is still usable?

1. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAVE TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

The chemical quality of white powders.

2. WHAT IS THE DEPENDENT VARIABLE?

Does a chemical reaction occur as a result of the reagent used [iron(III) chloride solution] or not?

3. HOW CAN YOU TEST THIS DEPENDENT VARIABLE? Does the reaction produce the lilac color characteristic of the reaction of the phenolic hydroxyl group with iron(III) chloride solution?

4. THIS IS THE ASSUMPTION (HYPOTHESIS): If the reaction is performed with white powder containing salicylic acid (the independent variable changes as intended), then a lilac color will appear during the reaction (the dependent variable will change in this way).

5. HOW CAN THE INDEPENDENT VARIABLE CHANGE?

|  |  |
| --- | --- |
| Experiment II.a: Substance marked 2. + 3-4 drops of iron(III) chloride solution | Experiment II.b: Substance marked 3. + 3-4 drops of iron(III) chloride solution |
| number of repetitions in class: | number of repetitions in class: |

6. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with a **X** sign!

The surface area of the watch glass or soda bottle cap.

The amount of salicylic acid and unknown white substances.

The volume of the iron(III) chloride solution.  The time elapsed after adding the reagent.

The concentration of the iron(III) chloride solution.

7. THE STEPS OF THE EXPERIMENTS:

1. Add 3-4 drops of iron(III) chloride solution to the white powder in the watch glass marked 2.
2. Observe and note the color that develops.
3. Add 3-4 drops of iron(III) chloride solution to the white powder in the watch glass marked 3.
4. Observe and note the color that develops.

**After the experiments are done, write down your observations and explanations. Draw a conclusion too.**

8. OBSERVATION:

When the reagent is added to the white powder marked 2., the color yellowish brown appears.

When the reagent is added to the white powder marked 3., the color lilac appears.

9. Explanation:

The reaction of iron(III) ions with compounds containing phenolic hydroxyl groups produces a characteristic lilac color. Phenolic hydroxyl groups are found in salicylic acid, but not in aspirin tablets.

10. CONCLUSION:

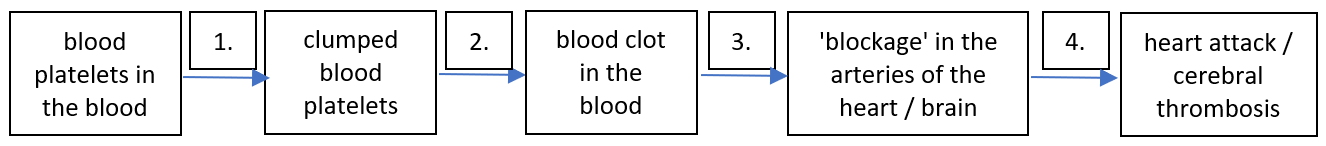
The white powder marked 3. is an expired aspirin tablet, as salicylic acid can be detected in it.

The white powder marked 2. is a usable aspirin tablet, as no salicylic acid was detected in it.

11. LET’S THINK!

"*Acetylsalicylic acid... inhibits platelet aggregation (clumping) in the blood, making it ideal for preventing cardiovascular thrombotic diseases.*"[[12]](#footnote-12) Based on the above quote, how does aspirin reduce the risk of heart attack and cerebral thrombosis? Of the steps shown in the flowchart below, which is the one that the aspirin tablet

prevents? 1.



Mark with an **X** the factors that, to the best of your knowledge, may increase the risk of heart attack and cerebral thrombosis!

High blood sugar levels  High cholesterol levels  High blood pressure

Smoking  Obesity ☐ Regular exercise

END OF THE 23rd STUDENT SHEETS AND TEACHER NOTES

**Student sheet 24: A chick from a boiled egg?**

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

Would you have thought that there is something in common between frying eggs, Alzheimer's disease, poisoning caused by heavy metal salts, and the fact that people who have a hangover or eat a lot of salty food are thirsty? But there is: they are all linked to changes in the structure of proteins, which prevents them from performing their original tasks (functions) because they become denaturated. If the change is reversible, the protein structure can be regenerated by diluting it with water. An example of such a process is dehydration, i.e., water withdrawal, in the case of consuming salty foods or alcohol. However, if an irreversible chemical process takes place, the protein is permanently denaturated and precipitates (coagulates). For example, a boiled egg will not turn into a chick...

Using the materials and tools on your trays, you will carry out model experiments to determine whether reversible or irreversible protein denaturation occurs in the following cases!

I. Someone's body struggles with a high fever for a long time.

II. Heavy metal poisoning occurs, for example, because vinegar-based food is left to stand in a copper pot.

III. Someone gets thirsty at the cinema after eating a lot of salty crisps.

MATERIALS AND EQUIPMENT: Egg white solution in 3 test tubes, copper(II) sulfate, sodium chloride, distilled water, 3 rubber stoppers, test tube rack, test tube clamp, 2 spoons, spirit burner, matches, gloves, safety goggles.

**After completing the experiments, write down your experiences. Complete the text by filling in the appropriate words, by underlining or framing the bold words, or by ~~crossing out~~ the incorrect ones.**

STEPS OF THE EXPERIMENTS:

|  |  |  |
| --- | --- | --- |
| Experiment 1:  (1) Pour 1 finger's width (approx. 2 cm3) of egg white solution into the test tube.  (2) Carefully heat the solution with a spirit burner until you notice a change.  (3) Dilute the contents of the test tube with distilled water, homogenize, and observe the phenomenon. | Experiment 2:  (1) Pour 1 finger's width (approx.  2 cm3) of egg white solution into the test tube.  (2) Add a small amount of copper(II) sulfate until you see a change and observe what happens.  (3) Dilute the contents of the test tube with distilled water, homogenize, and observe the phenomenon. | Experiment 3:  1) Pour 1 finger's width (approx. 2 cm3) of egg white solution into the test tube.  (2) Add a little sodium chloride until you see a change and observe what happens.  (3) Dilute the contents of the test tube with distilled water, homogenize and observe the phenomenon. |

**After carrying out the experiments, write down your experience, explanation and conclusion.**

1. OBSERVATION:

Experiment I.: A precipitate of color ……………………………. appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment II.: A precipitate of color ……………………………. appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment III.: A precipitate of color ……………………………. appears in the test tube, which **disappears/does not disappear** after dilution.

2. Explanation:

Experiment I.: **Reversible/irreversible** denaturation occurs under the influence of ………………………………………… because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment II.: **Reversible/irreversible** denaturation occurs under the influence of ………………………………………… because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment III.: **Reversible/irreversible** denaturation occurs under the influence of ………………………………………… because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

3. CONCLUSION: …………………………………………………………………………………………………………………………………………………..

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

4. LET’S THINK!

Below you will find descriptions of seven types of protein denaturation that can be encountered in everyday life. Decide what causes protein denaturation in each case and whether the change in protein structure can be classified as reversible (**R**) or irreversible (**I**).

|  |  |  |
| --- | --- | --- |
| DESCRIPTION | REASON | TYPE |
| 1. Concentrated nitric acid gets on someone's hands during an experiment. |  |  |
| 2. Someone becomes dehydrated after drinking alcohol. |  |  |
| 3. Someone touches a hot baking tray without oven gloves and burns their hand. |  |  |
| 4. Drain cleaner containing solid granular caustic soda splashes into someone's eye. |  |  |
| 5. in the past, someone drank water from pipes made of lead. |  |  |
| 6. Eggs harden during cooking. |  |  |
| 7. Copper sulfate is used in agriculture as a fungicide and bactericide. |  |  |

**Teacher notes for Student sheet 24: A chick from a boiled egg?**

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

Teachers are kindly asked to encourage their students to do experiments by highlighting the importance of experimentation in science and praising them when they think correctly.

Would you have thought that there is something in common between frying eggs, Alzheimer's disease, poisoning caused by heavy metal salts, and the fact that people who have a hangover or eat a lot of salty food are thirsty? But there is: they are all linked to changes in the structure of proteins, which prevents them from performing their original tasks (functions) because they become denaturated. If the change is reversible, the protein structure can be regenerated by diluting it with water. An example of such a process is dehydration, i.e., water withdrawal, in the case of consuming salty foods or alcohol. However, if an irreversible chemical process takes place, the protein is permanently denaturated and precipitates (coagulates). For example, a boiled egg will not turn into a chick...

Using the materials and tools on your trays, you will carry out model experiments to determine whether reversible or irreversible protein denaturation occurs in the following cases!

I. Someone's body struggles with a high fever for a long time.

II. Heavy metal poisoning occurs, for example, because vinegar-based food is left to stand in a copper pot.

III. Someone gets thirsty at the cinema after eating a lot of salty crisps.

MATERIALS AND EQUIPMENT: Egg white solution in 3 test tubes, copper(II) sulfate, sodium chloride, distilled water, 3 rubber stoppers, test tube rack, test tube clamp, 2 spoons, spirit burner, matches, gloves, safety goggles.

**After completing the experiments, write down your experiences. Complete the text by filling in the appropriate words, by underlining or framing the bold words, or by ~~crossing out~~ the incorrect ones.**

STEPS OF THE EXPERIMENTS:

|  |  |  |
| --- | --- | --- |
| Experiment 1:  (1) Pour 1 finger's width (approx. 2 cm3) of egg white solution into the test tube.  (2) Carefully heat the solution with a spirit burner until you notice a change.  (3) Dilute the contents of the test tube with distilled water, homogenize, and observe the phenomenon. | Experiment 2:  (1) Pour 1 finger's width (approx.  2 cm3) of egg white solution into the test tube.  (2) Add a small amount of copper(II) sulfate until you see a change and observe what happens.  (3) Dilute the contents of the test tube with distilled water, homogenize, and observe the phenomenon. | Experiment 3:  1) Pour 1 finger's width (approx. 2 cm3) of egg white solution into the test tube.  (2) Add a little sodium chloride until you see a change and observe what happens.  (3) Dilute the contents of the test tube with distilled water, homogenize and observe the phenomenon. |

**After carrying out the experiments, write down your experience, explanation and conclusion.**

1. OBSERVATION:

Experiment I.: A precipitate of color white appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment II.: A precipitate of color white / bluish appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment III.: A precipitate of color white appears in the test tube, which **disappears/does not disappear** after dilution.

2. Explanation:

Experiment I.: **Reversible/irreversible** denaturation occurs under the influence of heating because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment II.: **Reversible/irreversible** denaturation occurs under the influence of copper(II) sulfate because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment III.: **Reversible/irreversible** denaturation occurs under the influence of sodium chloride because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

3. CONCLUSION: Proteins denaturated irreversibly when exposed to high temperatures and heavy metal salts, and reversibly when exposed to light metal salts.

4. LET’S THINK!

Below you will find descriptions of seven types of protein denaturation that can be encountered in everyday life. Decide what causes protein denaturation in each case and whether the change in protein structure can be classified as reversible (**R**) or irreversible (**I**).

|  |  |  |
| --- | --- | --- |
| DESCRIPTION | REASON | TYPE |
| 1. Concentrated nitric acid gets on someone's hands during an experiment. | concentrated strong acid | I |
| 2. Someone becomes dehydrated after drinking alcohol. | ethyl alcohol | R |
| 3. Someone touches a hot baking tray without oven gloves and burns their hand. | high temperature | I |
| 4. Drain cleaner containing solid granular caustic soda splashes into someone's eye. | concentrated strong alkali | I |
| 5. in the past, someone drank water from pipes made of lead. | heavy metal salt | I |
| 6. Eggs harden during cooking. | high temperature | I |
| 7. Copper sulfate is used in agriculture as a fungicide and bactericide. | heavy metal salt | I |

**Student sheet 24: A chick from a boiled egg?**

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

Would you have thought that there is something in common between frying eggs, Alzheimer's disease, poisoning caused by heavy metal salts, and the fact that people who have a hangover or eat a lot of salty food are thirsty? But there is: they are all linked to changes in the structure of proteins, which prevents them from performing their original tasks (functions) because they become denaturated. If the change is reversible, the protein structure can be regenerated by diluting it with water. An example of such a process is dehydration, i.e., water withdrawal, in the case of consuming salty foods or alcohol. However, if an irreversible chemical process takes place, the protein is permanently denaturated and precipitates (coagulates). For example, a boiled egg will not turn into a chick...

Using the materials and tools on your trays, you will carry out model experiments to determine whether reversible or irreversible protein denaturation occurs in the following cases!

I. Someone's body struggles with a high fever for a long time.

II. Heavy metal poisoning occurs, for example, because vinegar-based food is left to stand in a copper pot.

III. Someone gets thirsty at the cinema after eating a lot of salty crisps.

MATERIALS AND EQUIPMENT: Egg white solution in 3 test tubes, copper(II) sulfate, sodium chloride, distilled water, 3 rubber stoppers, test tube rack, test tube clamp, 2 spoons, spirit burner, matches, gloves, safety goggles.

**After completing the experiments, write down your experiences. Complete the text by filling in the appropriate words, by underlining or framing the bold words, or by ~~crossing out~~ the incorrect ones.**

STEPS OF THE EXPERIMENTS:

|  |  |  |
| --- | --- | --- |
| Experiment 1:  (1) Pour 1 finger's width (approx. 2 cm3) of egg white solution into the test tube.  (2) Carefully heat the solution with a spirit burner until you notice a change.  (3) Dilute the contents of the test tube with distilled water, homogenize, and observe the phenomenon. | Experiment 2:  (1) Pour 1 finger's width (approx.  2 cm3) of egg white solution into the test tube.  (2) Add a small amount of copper(II) sulfate until you see a change and observe what happens.  (3) Dilute the contents of the test tube with distilled water, homogenize, and observe the phenomenon. | Experiment 3:  1) Pour 1 finger's width (approx. 2 cm3) of egg white solution into the test tube.  (2) Add a little sodium chloride until you see a change and observe what happens.  (3) Dilute the contents of the test tube with distilled water, homogenize and observe the phenomenon. |

**After carrying out the experiments, write down your experience, explanation and conclusion.**

1. OBSERVATION:

Experiment I.: A precipitate of color ……………………………. appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment II.: A precipitate of color ……………………………. appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment III.: A precipitate of color ……………………………. appears in the test tube, which **disappears/does not disappear** after dilution.

2. Explanation:

Experiment I.: **Reversible/irreversible** denaturation occurs under the influence of ………………………………………… because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment II.: **Reversible/irreversible** denaturation occurs under the influence of ………………………………………… because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment III.: **Reversible/irreversible** denaturation occurs under the influence of ………………………………………… because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

3. CONCLUSION: …………………………………………………………………………………………………………………………………………………..

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

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

4. HOW DID YOU REPLACE (MODEL) THE PROTEINS IN OUR BODIES IN THE EXPERIMENT?

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

5. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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

6. WHAT WAS THE DEPENDENT VARIABLE?

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

7. HOW COULD YOU TEST THIS DEPENDENT VARIABLE?

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

8. THIS WAS THE ASSUMPTION (HYPOTHESIS):

If ………………………………………………………………………………………………………………………………………. (the independent

variable changes as intended), then ………………………………………………………………………………………. (the dependent variable will change in this way).

9. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X**!

The volume of the protein solution.  The sequence of operations.

The person conducting the experiment.  The concentration of the protein solution.

10. LET’S THINK!

Below you will find descriptions of seven types of protein denaturation that can be encountered in everyday life. Decide what causes protein denaturation in each case and whether the change in protein structure can be classified as reversible (**R**) or irreversible (**I**).

|  |  |  |
| --- | --- | --- |
| DESCRIPTION | REASON | TYPE |
| 1. Concentrated nitric acid gets on someone's hands during an experiment. |  |  |
| 2. Someone becomes dehydrated after drinking alcohol. |  |  |
| 3. Someone touches a hot baking tray without oven gloves and burns their hand. |  |  |
| 4. Drain cleaner containing solid granular caustic soda splashes into someone's eye. |  |  |
| 5. in the past, someone drank water from pipes made of lead. |  |  |
| 6. Eggs harden during cooking. |  |  |
| 7. Copper sulfate is used in agriculture as a fungicide and bactericide. |  |  |

**Teacher notes for Student sheet 24: A chick from a boiled egg?**

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

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

Would you have thought that there is something in common between frying eggs, Alzheimer's disease, poisoning caused by heavy metal salts, and the fact that people who have a hangover or eat a lot of salty food are thirsty? But there is: they are all linked to changes in the structure of proteins, which prevents them from performing their original tasks (functions) because they become denaturated. If the change is reversible, the protein structure can be regenerated by diluting it with water. An example of such a process is dehydration, i.e., water withdrawal, in the case of consuming salty foods or alcohol. However, if an irreversible chemical process takes place, the protein is permanently denaturated and precipitates (coagulates). For example, a boiled egg will not turn into a chick...

Using the materials and tools on your trays, you will carry out model experiments to determine whether reversible or irreversible protein denaturation occurs in the following cases!

I. Someone's body struggles with a high fever for a long time.

II. Heavy metal poisoning occurs, for example, because vinegar-based food is left to stand in a copper pot.

III. Someone gets thirsty at the cinema after eating a lot of salty crisps.

MATERIALS AND EQUIPMENT: Egg white solution in 3 test tubes, copper(II) sulfate, sodium chloride, distilled water, 3 rubber stoppers, test tube rack, test tube clamp, 2 spoons, spirit burner, matches, gloves, safety goggles.

**After completing the experiments, write down your experiences. Complete the text by filling in the appropriate words, by underlining or framing the bold words, or by ~~crossing out~~ the incorrect ones.**

STEPS OF THE EXPERIMENTS:

|  |  |  |
| --- | --- | --- |
| Experiment 1:  (1) Pour 1 finger's width (approx. 2 cm3) of egg white solution into the test tube.  (2) Carefully heat the solution with a spirit burner until you notice a change.  (3) Dilute the contents of the test tube with distilled water, homogenize, and observe the phenomenon. | Experiment 2:  (1) Pour 1 finger's width (approx.  2 cm3) of egg white solution into the test tube.  (2) Add a small amount of copper(II) sulfate until you see a change and observe what happens.  (3) Dilute the contents of the test tube with distilled water, homogenize, and observe the phenomenon. | Experiment 3:  1) Pour 1 finger's width (approx. 2 cm3) of egg white solution into the test tube.  (2) Add a little sodium chloride until you see a change and observe what happens.  (3) Dilute the contents of the test tube with distilled water, homogenize and observe the phenomenon. |

**After carrying out the experiments, write down your experience, explanation and conclusion.**

1. OBSERVATION:

Experiment I.: A precipitate of color white appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment II.: A precipitate of color white / bluish appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment III.: A precipitate of color white appears in the test tube, which **disappears/does not disappear** after dilution.

2. Explanation:

Experiment I.: **Reversible/irreversible** denaturation occurs under the influence of heating because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment II.: **Reversible/irreversible** denaturation occurs under the influence of copper(II) sulfate because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment III.: **Reversible/irreversible** denaturation occurs under the influence of sodium chloride because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

3. CONCLUSION: Proteins denaturated irreversibly when exposed to high temperatures and heavy metal salts, and reversibly when exposed to light metal salts.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

4. HOW DID YOU REPLACE (MODEL) THE PROTEINS IN OUR BODIES IN THE EXPERIMENT?

With egg white solution.

5. WHAT WAS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

Destructive effects/external influences causing protein denaturation (high temperature, heavy and light metal salts).

6. WHAT WAS THE DEPENDENT VARIABLE?

The type of protein denaturation – reversible or irreversible.

7. HOW COULD YOU TEST THIS DEPENDENT VARIABLE?

We added distilled water to the denatured protein and homogenized the resulting system.

8. THIS WAS THE ASSUMPTION (HYPOTHESIS):

If we expose our protein sample to some kind of destructive effect (the independent

variable changes as intended), then the protein will denaturate reversibly or irreversibly (the dependent variable will change in this way).

9. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X**!

The volume of the protein solution.  The sequence of operations.

The person conducting the experiment.  The concentration of the protein solution.

10. LET'S THINK!

Below you will find descriptions of seven types of protein denaturation that can be encountered in everyday life. Decide what causes protein denaturation in each case and whether the change in protein structure can be classified as reversible (**R**) or irreversible (**I**).

|  |  |  |
| --- | --- | --- |
| DESCRIPTION | REASON | TYPE |
| 1. Concentrated nitric acid gets on someone's hands during an experiment. | concentrated strong acid | I |
| 2. Someone becomes dehydrated after drinking alcohol. | ethyl alcohol | R |
| 3. Someone touches a hot baking tray without oven gloves and burns their hand. | high temperature | I |
| 4. Drain cleaner containing solid granular caustic soda splashes into someone's eye. | concentrated strong alkali | I |
| 5. in the past, someone drank water from pipes made of lead. | heavy metal salt | I |
| 6. Eggs harden during cooking. | high temperature | I |
| 7. Copper sulfate is used in agriculture as a fungicide and bactericide. | heavy metal salt | I |

**Student sheet 24: A chick from a boiled egg?**

(type 3: experimental design following a scheme version for Group 3 students)

Would you have thought that there is something in common between frying eggs, Alzheimer's disease, poisoning caused by heavy metal salts, and the fact that people who have a hangover or eat a lot of salty food are thirsty? But there is: they are all linked to changes in the structure of proteins, which prevents them from performing their original tasks (functions) because they become denaturated. If the change is reversible, the protein structure can be regenerated by diluting it with water. An example of such a process is dehydration, i.e., water withdrawal, in the case of consuming salty foods or alcohol. However, if an irreversible chemical process takes place, the protein is permanently denaturated and precipitates (coagulates). For example, a boiled egg will not turn into a chick...

Using the materials and tools on your trays, you will carry out model experiments to determine whether reversible or irreversible protein denaturation occurs in the following cases!

I. Someone's body struggles with a high fever for a long time.

II. Heavy metal poisoning occurs, for example, because vinegar-based food is left to stand in a copper pot.

III. Someone gets thirsty at the cinema after eating a lot of salty crisps.

MATERIALS AND EQUIPMENT: Egg white solution in 3 test tubes, copper(II) sulfate, sodium chloride, distilled water, 3 rubber stoppers, test tube rack, test tube clamp, 2 spoons, spirit burner, matches, gloves, safety goggles.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

1. HOW COULD YOU REPLACE (MODEL) THE PROTEINS IN OUR BODIES IN THE EXPERIMENT?

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

2. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

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

3. WHAT IS THE DEPENDENT VARIABLE?

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

4. HOW COULD YOU TEST THIS DEPENDENT VARIABLE?

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

5. THIS IS THE ASSUMPTION (HYPOTHESIS):

If ………………………………………………………………………………………………………………………………………. (the independent

variable changes as intended), then ………………………………………………………………………………………. (the dependent variable will change in this way).

6. HOW CAN THE INDEPENDENT VARIABLE CHANGE? (Plan what needs to be put into the test tubes during each experiment!)

|  |  |  |
| --- | --- | --- |
| Experiment I.: | Experiment II.: | Experiment III.: |
| number of repetitions in class: | number of repetitions in class: | number of repetitions in class: |

7. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X**!

The volume of the protein solution.  The sequence of operations.

The person conducting the experiment.  The concentration of the protein solution.

8. THE STEPS OF THE EXPERIMENTS:

|  |  |  |
| --- | --- | --- |
| Experiment I.: | Experiment II.: | Experiment III.: |

**After completing the experiments, write down your experiences. Complete the text by filling in the appropriate words, by underlining or framing the bold words, or by ~~crossing out~~ the incorrect ones.**

9. OBSERVATION:

Experiment I.: A precipitate of color ……………………………. appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment II.: A precipitate of color ……………………………. appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment III.: A precipitate of color ……………………………. appears in the test tube, which **disappears/does not disappear** after dilution.

10. Explanation:

Experiment I.: **Reversible/irreversible** denaturation occurs under the influence of ………………………………………… because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment II.: **Reversible/irreversible** denaturation occurs under the influence of ………………………………………… because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment III.: **Reversible/irreversible** denaturation occurs under the influence of ………………………………………… because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

11. CONCLUSION: …………………………………………………………………………………………………………………………………………………

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

12. LET’S THINK!

Below you will find descriptions of seven types of protein denaturation that can be encountered in everyday life. Decide what causes protein denaturation in each case and whether the change in protein structure can be classified as reversible (**R**) or irreversible (**I**).

|  |  |  |
| --- | --- | --- |
| DESCRIPTION | REASON | TYPE |
| 1. Concentrated nitric acid gets on someone's hands during an experiment. |  |  |
| 2. Someone becomes dehydrated after drinking alcohol. |  |  |
| 3. Someone touches a hot baking tray without oven gloves and burns their hand. |  |  |
| 4. Drain cleaner containing solid granular caustic soda splashes into someone's eye. |  |  |
| 5. in the past, someone drank water from pipes made of lead. |  |  |
| 6. Eggs harden during cooking. |  |  |
| 7. Copper sulfate is used in agriculture as a fungicide and bactericide. |  |  |

**Teacher notes for Student sheet 24: A chick from a boiled egg?**

(type 3: experimental design following a scheme version for Group 3 students)

Teachers are kindly asked to encourage their students to answer questions about experiment design by highlighting its usefulness and praising them for thinking well.

Would you have thought that there is something in common between frying eggs, Alzheimer's disease, poisoning caused by heavy metal salts, and the fact that people who have a hangover or eat a lot of salty food are thirsty? But there is: they are all linked to changes in the structure of proteins, which prevents them from performing their original tasks (functions) because they become denaturated. If the change is reversible, the protein structure can be regenerated by diluting it with water. An example of such a process is dehydration, i.e., water withdrawal, in the case of consuming salty foods or alcohol. However, if an irreversible chemical process takes place, the protein is permanently denaturated and precipitates (coagulates). For example, a boiled egg will not turn into a chick...

Using the materials and tools on your trays, you will carry out model experiments to determine whether reversible or irreversible protein denaturation occurs in the following cases!

I. Someone's body struggles with a high fever for a long time.

II. Heavy metal poisoning occurs, for example, because vinegar-based food is left to stand in a copper pot.

III. Someone gets thirsty at the cinema after eating a lot of salty crisps.

MATERIALS AND EQUIPMENT: Egg white solution in 3 test tubes, copper(II) sulfate, sodium chloride, distilled water, 3 rubber stoppers, test tube rack, test tube clamp, 2 spoons, spirit burner, matches, gloves, safety goggles.

**In real science, evidence is gathered through well-designed experiments. To avoid being misled by pseudo-scientific hoaxes, it's good to understand how to design an experiment correctly. To do this, answer the following questions.**

1. HOW COULD YOU REPLACE (MODEL) THE PROTEINS IN OUR BODIES IN THE EXPERIMENT?

With egg white solution.

2. WHAT IS THE INDEPENDENT VARIABLE THAT YOU HAD TO CHANGE IN THE EXPERIMENTS?

**YOU ARE ONLY ALLOWED TO CHANGE ONE FACTOR AT A TIME!**

Destructive effects/external influences causing protein denaturation (high temperature, heavy and light metal salts).

3. WHAT IS THE DEPENDENT VARIABLE?

The type of protein denaturation – reversible or irreversible.

4. HOW COULD YOU TEST THIS DEPENDENT VARIABLE?

We add distilled water to the denatured protein and homogenize the resulting system.

5. THIS IS THE ASSUMPTION (HYPOTHESIS):

If we expose our protein sample to some kind of destructive effect (the independent

variable changes as intended), then the protein will denaturate reversibly or irreversibly (the dependent variable will change in this way).

6. HOW CAN THE INDEPENDENT VARIABLE CHANGE? (Plan what needs to be put into the test tubes during each experiment!)

|  |  |  |
| --- | --- | --- |
| Experiment I.: egg white solution + heating until change is observed +  dilution with distilled water + homogenization | Experiment II.: egg white solution + copper(II) sulfate until change is observed +  dilution with distilled water + homogenization | Experiment III.: egg white solution + sodium chloride until change is observed +  dilution with distilled water + homogenization |
| number of repetitions in class: | number of repetitions in class: | number of repetitions in class: |

7. WHICH OF THE FOLLOWING CONSTANTS SHOULD BE THE SAME IN ALL EXPERIMENTS? Mark with an **X**!

The volume of the protein solution.  The sequence of operations.

The person conducting the experiment.  The concentration of the protein solution.

8. THE STEPS OF THE EXPERIMENTS:

|  |  |  |
| --- | --- | --- |
| Experiment I.:  (1) Pour a finger's width of egg white solution into a test tube.  (2) Carefully begin to heat the solution with a spirit burner and observe what happens.  (3) Dilute the contents of the test tube with distilled water, homogenize, and observe the phenomenon. | Experiment II.:  (1) Pour a finger's width of egg white solution into a test tube.  (2) Add a small amount of copper(II) sulfate until you see a change, and observe what happens.  (3) Dilute the contents of the test tube with distilled water, homogenize, and observe the phenomenon. | Experiment III.:  (1) Pour a finger's width of egg white solution into a test tube.  (2) Add a small amount of sodium chloride until you see a change, and observe what happens.  (3) Dilute the contents of the test tube with distilled water, homogenize, and observe the phenomenon. |

**After completing the experiments, write down your experiences. Complete the text by filling in the appropriate words, by underlining or framing the bold words, or by ~~crossing out~~ the incorrect ones.**

9. OBSERVATION:

Experiment I.: A precipitate of color white appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment II.: A precipitate of color white / bluish appears in the test tube, which **disappears/does not disappear** after dilution.

Experiment III.: A precipitate of color white appears in the test tube, which **disappears/does not disappear** after dilution.

10. Explanation:

Experiment I.: **Reversible/irreversible** denaturation occurs under the influence of heating because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment II.: **Reversible/irreversible** denaturation occurs under the influence of copper(II) sulfate because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

Experiment III.: **Reversible/irreversible** denaturation occurs under the influence of sodium chloride because **secondary/primary** interactions have been rearranged, and **no new material is formed / new material is formed**.

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|  |  |  |
| --- | --- | --- |
| DESCRIPTION | REASON | TYPE |
| 1. Concentrated nitric acid gets on someone's hands during an experiment. | concentrated strong acid | I |
| 2. Someone becomes dehydrated after drinking alcohol. | ethyl alcohol | R |
| 3. Someone touches a hot baking tray without oven gloves and burns their hand. | high temperature | I |
| 4. Drain cleaner containing solid granular caustic soda splashes into someone's eye. | concentrated strong alkali | I |
| 5. in the past, someone drank water from pipes made of lead. | heavy metal salt | I |
| 6. Eggs harden during cooking. | high temperature | I |
| 7. Copper sulfate is used in agriculture as a fungicide and bactericide. | heavy metal salt | I |

END OF THE 24th STUDENT SHEETS AND TEACHER NOTES

1. Gertner Hajnalka; Wajand Judit: *Szerves kémiát érdekesen!: Kísérletek aszpirinnel.* In: Iskolakultúra, (2) 23-24. pp. 30-34. (1992) [↑](#footnote-ref-1)
2. [Az aspirin és a heparin hatása - Trombózis- és Hematológiai központ (tromboziskozpont.hu)](https://www.tromboziskozpont.hu/veralvadasgatlo-heparin-aspirin) (Last visited: 23.08.2024.) [↑](#footnote-ref-2)
3. Gertner Hajnalka; Wajand Judit: *Szerves kémiát érdekesen!: Kísérletek aszpirinnel.* In: Iskolakultúra, (2) 23-24. pp. 30-34. (1992) [↑](#footnote-ref-3)
4. [Az aspirin és a heparin hatása - Trombózis- és Hematológiai központ (tromboziskozpont.hu)](https://www.tromboziskozpont.hu/veralvadasgatlo-heparin-aspirin) (Last visited: 23.08.2024.) [↑](#footnote-ref-4)
5. Gertner Hajnalka; Wajand Judit: *Szerves kémiát érdekesen!: Kísérletek aszpirinnel.* In: Iskolakultúra, (2) 23-24. pp. 30-34. (1992) [↑](#footnote-ref-5)
6. [Az aspirin és a heparin hatása - Trombózis- és Hematológiai központ (tromboziskozpont.hu)](https://www.tromboziskozpont.hu/veralvadasgatlo-heparin-aspirin) (Last visited: 23.08.2024.) [↑](#footnote-ref-6)
7. Gertner Hajnalka; Wajand Judit: *Szerves kémiát érdekesen!: Kísérletek aszpirinnel.* In: Iskolakultúra, (2) 23-24. pp. 30-34. (1992) [↑](#footnote-ref-7)
8. [Az aspirin és a heparin hatása - Trombózis- és Hematológiai központ (tromboziskozpont.hu)](https://www.tromboziskozpont.hu/veralvadasgatlo-heparin-aspirin) (Last visited: 23.08.2024.) [↑](#footnote-ref-8)
9. Gertner Hajnalka; Wajand Judit: *Szerves kémiát érdekesen!: Kísérletek aszpirinnel.* In: Iskolakultúra, (2) 23-24. pp. 30-34. (1992) [↑](#footnote-ref-9)
10. [Az aspirin és a heparin hatása - Trombózis- és Hematológiai központ (tromboziskozpont.hu)](https://www.tromboziskozpont.hu/veralvadasgatlo-heparin-aspirin) (Last visited: 23.08.2024.) [↑](#footnote-ref-10)
11. Gertner Hajnalka; Wajand Judit: *Szerves kémiát érdekesen!: Kísérletek aszpirinnel.* In: Iskolakultúra, (2) 23-24. pp. 30-34. (1992) [↑](#footnote-ref-11)
12. [Az aspirin és a heparin hatása - Trombózis- és Hematológiai központ (tromboziskozpont.hu)](https://www.tromboziskozpont.hu/veralvadasgatlo-heparin-aspirin) (Last visited: 23.08.2024.) [↑](#footnote-ref-12)