**Test 4 and associated teacher’s notes**

[**MTA-ELTE Research Group on Inquiry-Based Chemistry Education**](https://mta.hu/kozoktatas-fejlesztesi-kutatasi-program/scientific-foundations-of-education-research-program-of-the-hungarian-academy-of-sciences-111618)

[**Research Programme for Public Education Development of the Hungarian Academy of Sciences**](https://mta.hu/kozoktatas-fejlesztesi-kutatasi-program/research-programme-for-public-education-development-of-the-hungarian-academy-of-sciences-111934)

*Note: More detailed instructions are available in Hungarian in the teacher’s guides, under the title “T4 teszt és javítási útmutatója” for T4 at* [Természettudományos Oktatásmódszertani Centrum](https://ttomc.elte.hu/publications/92) *and at*

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

Test 4 (May, 2025)

Number of school:…(A) Number of teacher:…(B) Number of group:…(C) Number of student: …(D)

The aim of our research is to make the teaching of chemistry as interesting and effective as possible.

**Thank you f**or completing this test to the best of your ability, as this will help us in our work.

Please write your answers on this sheet only; **do not use separate sheets of paper**! You may make corrections after crossing out, if necessary.

**1. a)** Mark with an **X** the square(s) in front of the name(s) of the process(es) that occur when we pour 40% by volume of cognac onto a dish and set it alight!

CQ

[ ]  endothermic physical [ ]  exothermic physical

 [ ]  endothermic chemical [ ]  exothermic chemical

**1. b)** Why does a piece of paper dipped in a 96% ethyl alcohol-water mixture burn to ashes, but a piece of paper dipped in a 40% ethyl alcohol-water mixture does not, after we light them?

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CR

**2.** Let's say you want to convince a friend that drinking alkaline water is pointless and even harmful. One reason for this is that alkaline water reacts with stomach acid, which is capable of neutralizing large amounts of alkaline water. The body must replenish the depleted stomach acid, as it is needed for tasks such as digesting proteins.

You can replace the acid in the stomach with 50 cm3 of hydrochloric acid with a concentration of

0.1 mol/dm3. Your friend usually drinks two types of alkaline water. You want to measure in two experiments how much (what volume) of one and the other alkaline water is neutralized by stomach acid. In addition to the two types of alkaline water, you have hydrochloric acid with a concentration of 0.1 mol/dm3, a suitable acid-base indicator, beakers of the required volume, volumetric measuring devices and droppers, and glass rods. Think about how you could carry out the two experiments, then answer the following questions!

**a)** What would you **change** in the two experiments? (What would be the difference between the two experiments?)

CS

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

**b)** Put a **+** sign **in front of the statement in the list below if you think it is true**, and a **-** sign **in front of the statement if you think it is not true**. (You can write another sign after a clear cross-out if you change your mind.)

The same volume beaker should be used in both experiments.

CT

The same volume of alkaline water should be used in both experiments

CU

The same volume of hydrochloric acid should be used in both experiments.

CV

The same volume of acid-base indicator should be used in both experiments.

CW

**c)** Which **two substances** would you put into the beakers at the start of both experiments?

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CX

**d)** What **change in quantity** would the change you described in point a) **cause** during the two experiments?

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

CY

**e)** Which **substance** **could you use to demonstrate the change in quantity described in point d)**?

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

CZ

**f)** How would you determine (in both cases) **the volume of alkaline water** neutralized by stomach

DA

acid?……………………………………………………………………………………………………………………..…………..

**3. a)** What **functional group** is present in glucose that causes it to give a positive Fehling's test?

DB

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

**3. b)** Apart from those mentioned in task 3a), what **other types of functional groups are there** in glucose?

DC

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

**4.** What can be added to show the presence of **iodine** in an **aqueous solution** with a color reaction?

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

DD

**5.** The active ingredient in aspirin is acetylsalicylic acid, which is an ester-type compound. When esters undergo hydrolysis, acid and hydroxy compounds (alcohol or phenol) are formed. So how is it possible that acetylsalicylic acid **hydrolyzes** into **two acids**, salicylic acid and acetic acid, when exposed to moist

air?……………………………………………………………………………………………………………………………………

DE

**6.** Arsenic trioxide is used in cancer therapy because it binds strongly to an enzyme protein called thioredoxin reductase, thereby altering its spatial structure. This has an adverse effect on the redox environment of cancer cells. Arsenic trioxide thus inhibits the growth of cancer cells in the body of a patient suffering from leukemia, thereby curing the disease. Does arsenic trioxide cause **reversible or irreversible** denaturation of the enzyme protein? **Why?** (Your answer is only valid if accompanied by an explanation.)

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DF

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**7. a)** Is it true that gasoline and water form two separate phases in a test tube even after shaking because gasoline has a lower density than water? **Your answer is only valid if accompanied by an explanation**.

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DG

**7. b)** Advertisements attribute numerous positive effects to products called lecithin, which are available in various forms and prices in various online stores. For example, one advertisement states: "*Lecithin is a natural phospholipid compound that plays a fundamental role in the structure of cell membranes and the proper functioning of the nervous system. This essential nutrient is involved in regulating fat metabolism and bile production and contributes to healthy brain function*." However, these products are usually mixtures of various compounds, and advertisements often contain half-truths or even false information. The attached figure shows the structural formula of phosphatidylcholine (lecithin). According to this, is it true that lecithin is a fat-like (i.e., apolar) substance, as stated in one online store? **Your statement is only valid if accompanied by an explanation.**

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DH

Please also answer the following questions!

* Write your end of first term grade in 10th grade chemistry in the box:

DI

* The bigger the number you circle, the more you like chemistry.

(1: you do not like it at all, 5: you really like it):

DJ

1 2 3 4 5

* The bigger the number, the more you consider it important to test ideas in sciences by experiments (1: not important at all; 5: very important):

1 2 3 4 5

DK

* The bigger the number, the more you agree with the following statement:

“I prefer the step-by-step experiments to the ones that I have to design.”

DL

1 2 3 4 5

Instructions given to the teachers to mark the students’ answers of the Test 4

Please complete the columns of the Excel spreadsheet with the marks obtained from following the instructions below. A student’s marks should be written in the appropriate row of the Excel spreadsheet.

Columns CQ-DH contain marks for students’ answers.

Columns DI contains the student’s end of first term grade in 9th grade chemistry.

Columns DJ-DL contain students’ attitude responses.

Abbreviations:

* DCK: disciplinary content knowledge;
* EDS: experimental design task

Column ‘CQ’ (task 1.a)

Correct answer 1:

[x]  endothermic physical [ ]  exothermic physical

 [ ]  endothermic chemical [x]  exothermic chemical

Correct answer 2:

[x]  endothermic physical [ ]  exothermic physical

 [x]  endothermic chemical [x]  exothermic chemical

*Note:* *The answer "endothermic chemical reaction" is acceptable because various endothermic decomposition processes obviously take place on the surface of the food when it is heated. However, this answer is only valid if the other two correct answers are also selected.*

Marks: 1

In any other case. Marks: 0

1 item: application (DCK task)

Column ‘CR’ (task 1.b)

Correct answer 1: Because in the 40% (by volume) [ethyl alcohol–water] mixture there is enough water whose evaporation during the burning of the [alcohol] removes heat / most of the heat [therefore the piece of paper does not reach its ignition temperature, unlike in the case of a 96% by volume ethyl alcohol–water mixture].

Correct answer 2: Any other answer with the same meaning as the above.

Marks: 1

In any other case. Marks: 0

1 item: understanding (DCK task)

*Note: Answers that do not refer to the fact that the water (through its evaporation) removes heat are not acceptable, because the question is not whether the 40% mixture can be ignited, but why the piece of paper dipped into it does not burn after being lit.*

Column ‘CS’ (task 2.a)

Correct answer 1: In the two experiments, I would use the two kinds of alkaline water. / Two kinds of alkaline water.

Correct answer 2: The quality/composition of the alkaline waters

Correct answer 3: Any other answer with the same meaning as the above.

Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘CT-CW’ (task 2.b)

Correct answer 1:

* The same volume beaker should be used in both experiments.

CT

* The same volume of alkaline water should be used in both experiments.

CU

**+** The same volume of hydrochloric acid should be used in both experiments.

CV

**+** The same volume of acid-base indicator should be used in both experiments.

CW

Correct answer 2:

* The same volume beaker should be used in both experiments.

CT

**+** The same volume of alkaline water should be used in both experiments.

CU

**–** The same volume of hydrochloric acid should be used in both experiments.

CV

**+** The same volume of acid-base indicator should be used in both experiments.

CW

Marks: 1+1+1+1

*Note: It is also acceptable if the student would put the two types of alkaline water of equal volume into the glasses with the indicator and titrate them with acid, because in principle it could also be calculated this way how much alkaline water is neutralized by 50 cm³ of acid. However, these answers will only earn points if they are not logically inconsistent with the answers given in points c)–f) below.*

Correct answer 3:

* The same volume beaker should be used in both experiments.

CT

**–** The same volume of alkaline water should be used in both experiments.

CU

**–** The same volume of hydrochloric acid should be used in both experiments.

CV

**+** The same volume of acid-base indicator should be used in both experiments.

CW

Marks: 1+1+1+1

*Note: A solution may also earn points if the respondent would use different volumes of acid in the two cases but titrate them with the alkaline waters, since it would still be possible to calculate the volume of alkaline water neutralized by 50 cm³ of acid. It is also possible that the respondent would titrate acid with alkaline water taken from the two different samples, but in unequal volumes. However, these answers will only earn points if they are not logically inconsistent with the answers given in points c)–f) below."*

In any other case. Marks: 0.

1 item: higher order cognitive skills (EDS task)

Column ‘CX’ (task 2.c)

Correct answer 1:

The [50 cm³] hydrochloric acid and the [acid–base] indicator.

*Note: This answer will receive points only if the student did not give the correct answer 2 combination for question 2.b), and it does not contradict the other answers. Mentioning them in reverse order is also acceptable, but only if both are mentioned together.*

*If the student entered both acid and alkaline water for question 2.c), then for subquestions 2 and 3 of question 2.b) they may receive only 0 points.*

Correct answer 2:

The two types of alkaline water / The alkaline waters and the [acid-base] indicator.

*Note: This answer will receive points only if the student gave the correct answer 2 or 3 combinations for question 2.b), and it does not contradict the other answers. Mentioning them in reverse order is also acceptable, but only if both are mentioned together.*

Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘CY’ (task 2.d)

Correct answer 1:

The volume/amount of alkaline water [needed to neutralize hydrochloric acid of the same volume and concentration].

*Note: This answer will receive points only if the student did not give the correct answer 2 combination for question 2.b), and it does not contradict the other answers.*

Correct answer 2:

The volume/amount of hydrochloric acid [needed to neutralize the alkaline waters].

*Note: This answer will receive points only if the student gave the correct answer 2 or 3 combinations for question 2.b), and it does not contradict the other answers.*

Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘CZ’ (task 2.e)

With an [acid-base] indicator

Marks: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘DA’ (task 2.f)

Correct answer 1: The amount needed to reach the neutral color of the acid-base indicator.
Correct answer 2: By the color change of the indicator.
Correct answer 3: After how many drops it becomes neutral.
Correct answer 4: By color change.
Correct answer 5: Until it becomes neutral / until it neutralizes.
Correct answer 6: By titration.

Correct answer 7: From the reaction of the indicator.
Correct answer 8: Based on its color.

*Note: One of the above correct answers 2-4, or something similar, can be accepted only if it is clear from the previous answers that the student understands the procedure of the measurement. However, an answer accepted as correct must in some way refer to the fact of the change.*

Mark: 1

In any other case. Marks: 0

1 item: higher order cognitive skills (EDS task)

Column ‘DB’ (task 3.a)

Correct answer 1: Formyl group.
Correct answer 2: Aldehyde group.
Correct answer 3: Glycosidic hydroxyl group.

Marks: 1

In any other case. Marks: 0

1 item: recall (DCK task)

Column ‘DC’ (task 3.b)

Correct answer 1: Hydroxyl group(s).
Correct answer 2: Hydroxyl group(s) and ether group..

Marks: 1

In any other case. Marks: 0

1 item: recall (DCK task)

Column ‘DD’ (task 4.)

Correct answer 1: Starch [solution].
Correct answer 2: When shaken with gasoline, a purple [colored solution forms].
Correct answer 3: Gasoline.
Correct answer 4: Vitamin C.
Correct answer 5: Carbon tetrachloride.
Correct answer 6: Hexane.

Marks: 1

In any other case. Marks: 0

1 item: recall (DCK task)

Column ‘DE’ (task 5.)

Correct answer 1: Salicylic acid contains a [phenolic] hydroxyl group.
Correct answer 2: Salicylic acid has a [phenolic] hydroxyl group.
Correct answer 3: Any other answer with the same meaning as the above.

Marks: 1

In any other case. Marks: 0

1 item: understanding (DCK task)

Column ‘DF’ (task 6)

Correct answer 1: Irreversible / causes irreversible denaturation, because it binds to [the protein] with a [strong] primary [chemical] bond.
Correct answer 2: Irreversible / causes irreversible denaturation, because a new substance is formed.

Correct answer 3: Any other answer with the same meaning as above.

Marks: 1

1 item: application (DCK task)

Column ‘DG’ (task 7.a)

Correct answer 1: No, but because the molecules/particles of gasoline are apolar, while those of water are polar.
Correct answer 2: No, but because their polarity is opposite / their molecules / particles have opposite polarity / their polarities differ.
Correct answer 3: True, but in addition, their polarity also differs.
Correct answer 4: No, because apolar gasoline does not dissolve in water.
Correct answer 5: No, because the two substances are insoluble in each other.

Marks: 1

In any other case. Marks: 0

1 item: understanding (DCK task)

Column ‘DH’ (task 7.a)

Correct answer 1: No, because it is amphipathic [particle] / has dual solubility.
Correct answer 2: No, because it has both polar and apolar parts.
Correct answer 3: No, because it is zwitterionic.
Correct answer 4: Partially true, because it has both polar and apolar parts.
Correct answer 5: Not really, because it also has a large polar part.
Correct answer 6: It has both apolar and polar parts.

Marks: 1

In any other case. Marks: 0

1 item: application (DCK task)

Column ‘DI’

The student’s end of first term grade in 10th grade chemistry.

Column ‘DJ’

The answer given by the student to the question how much he/she likes chemistry. (Insert the number circled by the student.)

Column ‘DK’

The answer given by the student to the question how important he/she thinks it is in science to test ideas by experiments. (Insert the number circled by the student.)

Columns ‘DL’

The answer given by the student to the question: “The bigger the number, the more you agree with the following statement: ‘I prefer the step-by-step experiments to the ones that I have to design.’” (Insert the number circled by the student.)

END OF EVALUATION OF THE TEST 4