State of Israel
Ministry of Education
Exam Type: *Bagrut*
Exam date: Summer 2022
Exam number: 37381
Attachments: (1) Periodic table
(2) Electronegativity table
(3) Formulas for calculations
(4) Functional groups
English translation (3)

מדינת ישראל
משרד החינוך
סוג הבחינה: בגרות
מועד הבחינה: קיץ תשפ"ב, 2022
מספר השאלון: 37381
נספחים: (1) הטבלה המחזורית
(2) טבלת אלקטרושליליות
(3) נוסחאות לחישובים
(4) קבוצות פונקציונליות
תרגום לאנגלית (3)

Note: This exam has special instructions. Answer the questions according to these instructions.

שימו לב: בבחינה זו יש הנחיות מיוחדות. יש לענות על השאלות על פי הנחיות אלה.

Chemistry

כימיה

Instructions

א. Duration of the exam: Three hours

ב. Exam structure and breakdown of points:
This exam has two parts.

Part One	—	40 points
Part Two	—	60 points
Total	—	100 points

ג. Material that may be used during the exam:
(1) A calculator (graphing calculators are permitted)
(2) Formula and data sheets (attached)
(3) A Hebrew-foreign language/ foreign language-Hebrew dictionary

ד. Special instructions:
(1) In Part One, there are nine questions.
For each of Questions 1-8, four possible answers are given and you must choose the correct answer.
Mark the correct answers on the answer sheet at the end of the answer booklet (page 19).
Answer the items in Question 9 according to the instructions.
(2) In Part Two, there are five questions.
You must answer three of them.

Write in the answer booklet only. Write the word "טיוטה" at the top of each page you use as a draft page. If you write any draft material outside the answer booklet, your exam may be disqualified.

Good Luck!

הוראות

א. משך הבחינה: שלוש שעות.

ב. מבנה השאלון ומפתח ההערכה:
בשאלון זה שני פרקים.

פרק ראשון	–	40 נקודות
פרק שני	–	60 נקודות
סך הכל	–	100 נקודות

ג. חומר עזר מותר בשימוש:
(1) מחשבון (כולל מחשבון גרפי).
(2) דפי נוסחאות ונתונים (מצורפים).
(3) מילון עברי-לועזי / לועזי-עברי.

ד. הוראות מיוחדות:
(1) בפרק הראשון יש תשע שאלות.
בכל אחת מן השאלות 1-8 מוצגות ארבע תשובות, ומהן יש לבחור בתשובה הנכונה.
את התשובות הנכונות יש לסמן בתשובון שבסוף מחברת הבחינה (עמוד 19).
בשאלה 9 יש לענות על הסעיפים לפי ההנחיות.
(2) בפרק השני יש חמש שאלות. יש לענות על שלוש מהן.

יש לכתוב במחברת הבחינה בלבד. יש לרשום "טיוטה" בראש כל עמוד המשמש טיוטה. כתיבת טיוטה בדפים שאינם במחברת הבחינה עלולה לגרום לפסילת הבחינה.

בהצלחה!

Questions

Part One (40 points)

Answer all eight questions 1-8.

If you answer at least six questions correctly you will receive the full 20 points (each question—$3\frac{1}{3}$ points).

Before you answer a question, read all the possible answers.

Each question is given four possible answers. Choose the correct one.

* Mark the answer you chose on the answer sheet on the inside cover at the end of the answer booklet (page 19).
* For each question, use a pen to mark an × in the box below the letter (א-ד) that represents the answer you chose.
* Mark an × in only one box for each question.
* If you want to erase your answer, fill in the whole box like this: ■ .
* Do **not** use White-Out to erase answers.
* **Note: In order to limit the need to erase answers on the answer sheet, we recommend that you first mark the correct answers inside the exam booklet itself and only later mark them on the answer sheet.**

1. Consider two sodium isotopes: ^{22}Na and ^{23}Na .

Which of the following statements is correct?

א. The isotope ^{23}Na has a greater nuclear charge than the isotope ^{22}Na .

ב. The isotope ^{22}Na has fewer neutrons than the isotope ^{23}Na .

ג. The isotope ^{23}Na has more electrons than the isotope ^{22}Na .

ד. The isotope ^{22}Na has fewer protons than the isotope ^{23}Na .

2. Consider the Lewis electron dot diagrams [נוסחאות ייצוג אלקטרונים], I-V, below:

I	II	III	IV	V
$[\mathrm{Ca}]^{2+}$	$\left[:\overset{..}{\underset{..}{\mathrm{Cl}}}:\right]^{-}$	$[\mathrm{Mg}\,:]^{2+}$	$\left[\vdots\underset{..}{\mathrm{F}}\cdot\right]^{-}$	$\left[:\overset{..}{\mathrm{O}}:\right]^{2-}$

Which of diagrams I-V correctly represent monoatomic (simple) ions?

א. I and II

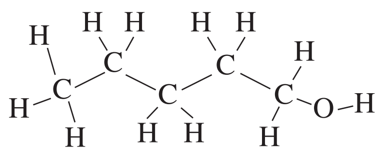
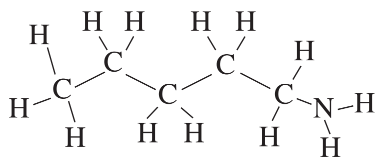
ב. III and IV

ג. III and V

ד. IV and V

/continued on page 3/

3. The following table presents information about two substances.

Substance	**Boiling point** (^oC)	**Full structural formula of the molecule**
1–pentanol	138	
1–aminopentane	104	

1-aminopentane has a lower boiling point than 1-pentanol.

What is the reason for this?

א. A molecule of 1-aminopentane has a smaller surface area than a molecule of 1-pentanol.

ב. A molecule of 1-aminopentane has a smaller electron cloud than a molecule of 1-pentanol.

ג. The hydrogen bonds formed between molecules of 1-aminopentane are weaker than the hydrogen bonds formed between molecules of 1-pentanol.

ד. A molecule of 1-aminopentane has fewer points where hydrogen bonds can form than a molecule of 1-pentanol.

4. A researcher heated 1.125 grams of the solid copper nitrate $Cu(NO_3)_{2(s)}$ $\left(M_w = 187.5\frac{g}{mol}\right)$.
During the heating process the following reaction took place:

$$Cu(NO_3)_{2(s)} \longrightarrow CuO_{(s)} + 2NO_{2(g)} + \frac{1}{2}O_{2(g)}$$

The copper nitrate reacted to completion.

Which statement about the reactants is correct?

א. 0.38 grams of the solid $CuO_{(s)}$ $\left(M_w = 79.5\frac{g}{mol}\right)$ $CuO_{(s)}$ were formed.

ב. 0.006 moles of $NO_{2(g)}$ were formed.

ג. 0.048 moles of oxygen were formed.

ד. A total of 0.015 moles of <u>gases</u> were formed in this reaction.

/continued on page 4/

5. In an experiment, two beakers, Beaker A and Beaker B, were placed on a balance.

Beaker A contained a solution of silver nitrate, $AgNO_{3(aq)}$, and **Beaker B** contained a solution of sodium chloride, $NaC\ell_{(aq)}$.

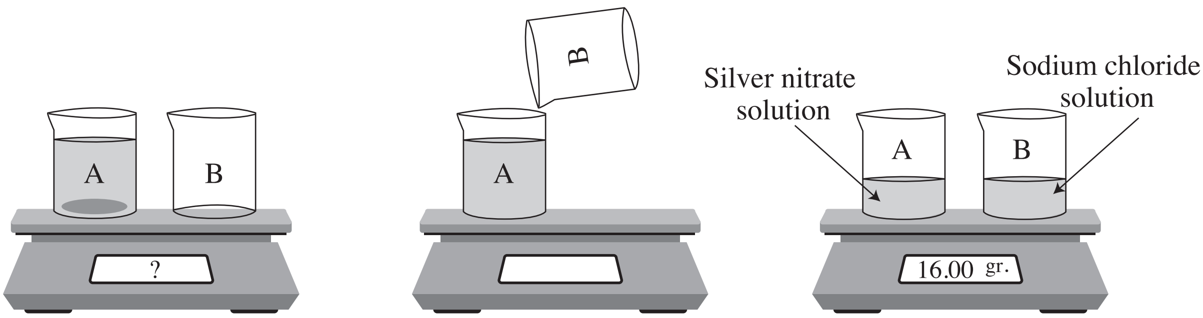
The total mass of the substances and the beakers as measured by the balance was 16.0 grams (see Figure I).

All the solution in Beaker B was poured into the solution in Beaker A, and then the empty Beaker B and Beaker A, in which a reaction had taken place, were placed on the balance (see Figures II and III).

The equation of the reaction is:

$$Ag^{+}_{(aq)} + NO^{-}_{3(aq)} + Na^{+}_{(aq)} + C\ell^{-}_{(aq)} \longrightarrow AgC\ell_{(s)} + Na^{+}_{(aq)} + NO^{-}_{3(aq)}$$

The following figures, I-III, describe the three steps in this experiment.



III **II** **I**

What was the total mass measured by the balance when the reaction was complete (Figure III)?

א. a mass of more than 16.0 grams

ב. a mass of less than 16.0 grams

ג. a mass of 16.0 grams

ד. The total mass cannot be determined without information about the concentration and volume of the solutions.

6. Researchers dissolved 2.96 grams of magnesium nitrate, $Mg(NO_3)_{2(s)}$, in 100 ml of a 0.1M sodium nitrate solution, $NaNO_{3(aq)}$.

The molar mass of magnesium nitrate is: $M_{w_{Mg(NO_3)_2}} = 148 \frac{g}{mo\ell}$.

What is the concentration of $NO^{-}_{3(aq)}$ ions in the solution after dissolution?

א. 0.5M

ב. 0.4M

ג. 0.3M

ד. 0.2M

/continued on page 5/

7. Consider the following ΔH^0 values for the combustion reactions (1)-(2):

(1) $N_{2(g)} + 2O_{2(g)} \longrightarrow 2NO_{2(g)}$ $\Delta H_1^0 = +66.4kJ$

(2) $2NO_{(g)} + O_{2(g)} \longrightarrow 2NO_{2(g)}$ $\Delta H_2^0 = -114.4kJ$

Consider Reaction (3):

(3) $N_{2(g)} + O_{2(g)} \longrightarrow 2NO_{(g)}$ $\Delta H_3^0 = ?$

What is the value of ΔH_3^0 for Reaction (3)?

א. -180.8 kJ

ב. $+180.8$ kJ

ג. -48.0 kJ

ד. $+48.0$ kJ

8. In an experiment, two gases, ammonia, $NH_{3(g)}$, and hydrogen chloride, $HC\ell_{(g)}$, were mixed, and a reaction took place. The product obtained was the ionic solid ammonium chloride, $NH_4C\ell_{(s)}$.
The equation of the reaction that occurred is:

$$NH_{3(g)} + HC\ell_{(g)} \longrightarrow NH_4C\ell_{(s)}$$

Which statement is correct?

א. In this reaction, ammonia, $NH_{3(g)}$, is the oxidizer.

ב. In this reaction, ammonia, $NH_{3(g)}$, is the base.

ג. In this reaction, hydrogen chloride, $HC\ell_{(g)}$, is the oxidizer.

ד. In this reaction, hydrogen chloride, $HC\ell_{(g)}$, is the base.

/continued on page 6/

Analysis of a passage from a scientific article — Required

9. Read the passage below and answer the items that follow, as directed (required question—20 points).

Hydrogen, the fuel of the future

Most scientists agree that the rise in atmospheric temperature in the current century is related to global warming and to burning large quantities of fuels composed mainly of carbon compounds (fossil fuels). Burning these fuels releases energy that is readily available. When fuels burn, carbon dioxide, $CO_{2(g)}$, which is a greenhouse gas, is released into the atmosphere. Greenhouse gases trap radiation that is reflected off planet Earth, causing the planet to heat up.

UN climate conferences have discussed reducing carbon dioxide emissions by 2050 in an effort to slow global warming. One of the possibilities under discussion is the production of energy by burning (a reaction with oxygen, $O_{2(g)}$) the gas hydrogen, $H_{2(g)}$, instead of burning fuels that contain carbon compounds.

Hydrogen does not exist on Earth in its elementary form, so it must be produced from various compounds, using chemical processes that require energy.

Hydrogen is often named according to its method of production, for example:
Gray hydrogen: *Gray hydrogen* is the cheapest hydrogen and it can be produced from natural gas. The main component of natural gas is methane, $CH_{4(g)}$.
When methane reacts with steam, $H_2O_{(g)}$, at high pressure, two gases are produced: carbon dioxide, $CO_{2(g)}$, which is released into the atmosphere, and hydrogen, $H_{2(g)}$, which is collected and stored in tanks.
Blue hydrogen: *Blue hydrogen* is produced using the same process as *gray hydrogen*, but the gas $CO_{2(g)}$ produced in the process is collected and not released into the atmosphere. There are several technologies under development for collecting and utilizing carbon dioxide.
One of the problems with the production process of *gray hydrogen* and *blue hydrogen* is the possibility that the methane, $CH_{4(g)}$, which is also a greenhouse gas, might escape into the atmosphere.
Green hydrogen: *Green hydrogen* is produced using electricity to decompose water under suitable conditions. The only products of this reaction are hydrogen and oxygen. This process requires energy which is obtained from renewable energy sources such as solar and wind energy.

Hydrogen can be used as a fuel, or in other words, burning hydrogen produces energy that can be used to power heavy industry and large vehicles.
Using hydrogen as a fuel is expected to create several problems:
– Hydrogen produced in its gaseous state must be stored in large tanks that are resistant to high pressure.
– To store hydrogen in its liquid state, it must be cooled to the very low temperature (20.3K) at which it becomes liquid.
– When hydrogen burns in the air, another reaction takes place, between the oxygen, $O_{2(g)}$, and the nitrogen, $N_{2(g)}$, in the air. This reaction produces nitrogen dioxide, $NO_{2(g)}$, which is another undesirable greenhouse gas.

(Note: The passage continues on the next page, and is followed by the questions.)

/continued on page 7/

Hydrogen can be used as a fuel in cars that have a special device installed in them. In this device an oxidation-reduction reaction takes place between the hydrogen (gas) and the oxygen (gas) from the air. This reaction takes place on the surface of a solid catalyst [זרז].

Around the globe there is a growing industry of hydrogen-fueled cars, and rapid fueling stations for hydrogen cars are being built. Hydrogen-fueled cars could eventually compete with electric cars, which are powered by an electric battery and take a long time to charge.

Only a very small proportion of world energy consumption is currently based on hydrogen. The next few years may see more countries adopting hydrogen as an energy source.

Adapted from: Dewan Angela (2021). *Green hydrogen could be the fuel of the future. Here's why it's not yet a silver bullet*. CNN, August 31.

א. Is burning fuels that contain carbon compounds an endothermic reaction? Explain your answer based on the passage.

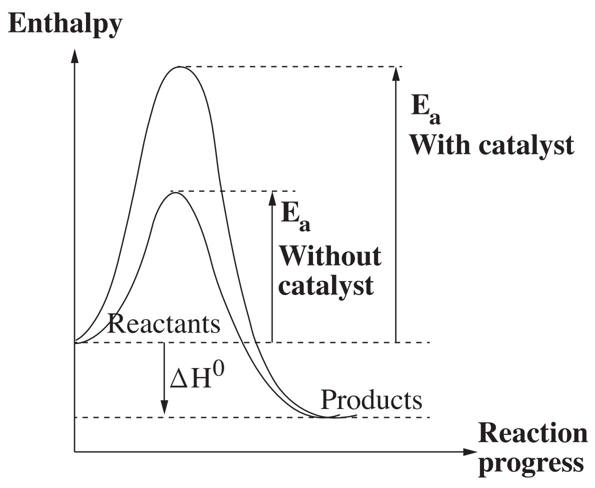
ב. What is the possible product of burning hydrogen: carbon dioxide, carbon monoxide, or water? Explain your answer.

ג. Write a balanced equation for the process of producing the gas *gray hydrogen*.

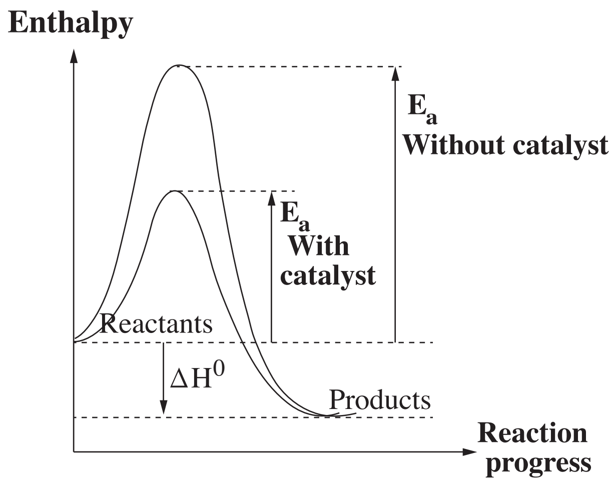
ד. Determine which is the oxidizer and which is the reducer in the reaction you formulated in Item ג. Explain your answer.

ה. Determine the sign of ΔH^0 for the reaction that occurs in the production of *green hydrogen*. Explain your answer based on the passage.

ו. Consider the graphs, I and II, below. Determine which graph correctly describes the effect of the catalyst on the reaction that takes place inside the device installed in hydrogen-fueled cars. Explain your answer.



Graph II



Graph I

E_a – Activation energy

(Note: This question continues on the next page.)

/continued on page 8/

Choose **either** Item ז **or** Item ח.

ז. In the production process of *blue hydrogen* 1 tonne (metric ton) of methane, $CH_{4(g)}$, reacted.
The carbon dioxide, $CO_{2(g)}$, produced in this process was collected.
Was the mass of carbon dioxide obtained in the reaction greater or smaller than 1 tonne?
Provide detailed calculations or explain in words.
Given: 1 tonne = 1×10^6 grams

ח. According to the passage, hydrogen changes state from gas to liquid at a temperature of 20.3K at atmospheric pressure.
Is the boiling point of oxygen under the same conditions higher than 20.3K or lower than 20.3K ?
Explain your answer. Discuss the forces operating between the molecules of each of the elements in the liquid state.

/continued on page 9/

Part 2 (60 points)

Answer three of the questions 10-14 (each question—20 points).

Structure and Bonding, Stoicheometry (Calculations), Energy

10. This question is about substances called fire retardants [מעכבי בעירה].
Domestic fire extinguishers contain gases, powders, or foams that retard combustion.
In the past, a gas with the formula $CBrF_{3(g)}$ was used as a fire retardant.
It has now been replaced with a mixture of three gases: $Ar_{(g)}$, $CF_{4(g)}$, $CHC\ell_2CF_{3(g)}$.

א. Provide Lewis electron dot diagrams for the molecules $CBrF_3$, $CHC\ell_2CF_3$ and CF_4 .

The following table presents the boiling points of two substances and the spatial shape of each of the molecules:

Substance (at room temperature)	**Boiling point** (°C)	**Spatial shape of the molecule**
$CBrF_{3(g)}$	−58	tetrahedron
$CF_{4(g)}$	−128	tetrahedron

ב. List two factors that cause the difference in boiling point between the two substances.

ג. Explain how each of the two factors you listed in Item ב affects the strength of the forces operating between the molecules.

Powders used to put out large fires contain mainly aluminum hydroxide, $A\ell(OH)_{3(s)}$, and magnesium hydroxide, $Mg(OH)_{2(s)}$. Aircraft drop these powders mixed with a red dye onto fires.
At high temperatures, the compound $A\ell(OH)_{3(s)}$ decomposes into the solid aluminum oxide, $A\ell_2O_{3(s)}$, and water vapor.
At high temperatures, the compound $Mg(OH)_{2(s)}$ decomposes into the solid magnesium oxide, $MgO_{(s)}$, and water vapor.

ד. Write a balanced equation for the decomposition of $A\ell(OH)_{3(s)}$.

ה. Write a balanced equation for the decomposition of $Mg(OH)_{2(s)}$.

ו. In Experiment 1, 3.9 grams of $A\ell(OH)_{3(s)}$ were heated. The material decomposed completely.
How many moles of water vapor were obtained in this reaction? Provide detailed calculations.

ז. In Experiment 2, a known mass of $Mg(OH)_{2(s)}$ was heated. The material decomposed completely. The number of moles of water vapor obtained in the reaction was identical to the number of moles of water vapor which you calculated in Item ו.
Was the number of moles of $Mg(OH)_{2(s)}$ which decomposed in Experiment 2 identical to the number of moles of $A\ell(OH)_{3(s)}$ which decomposed in Experiment 1? Provide detailed calculations or explain in words.

ח. The two decomposition reactions, of $A\ell(OH)_{3(s)}$ and of $Mg(OH)_{2(s)}$, help lower the temperature in the area that is on fire. Are the decomposition reactions endothermic or exothermic? Explain your answer.

/continued on page 10/

Structure and Bonding, Energy

11. This question is about two substances: ethanol, $C_2H_5OH_{(\ell)}$ and potassium chloride, $KC\ell_{(s)}$.

The following six illustrations, 1-6, partially describe a number of microscopic structures:

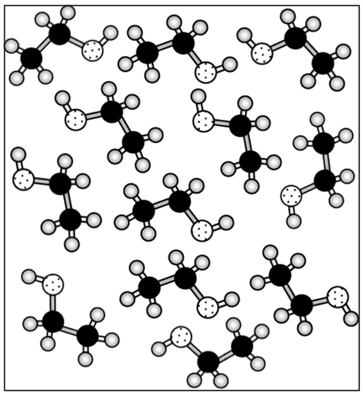


Figure 3

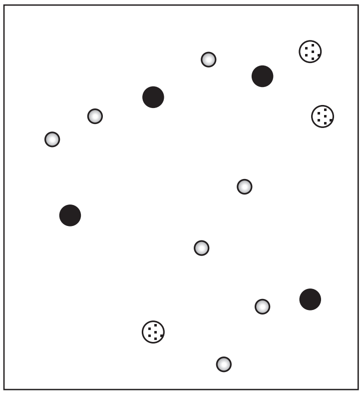


Figure 2

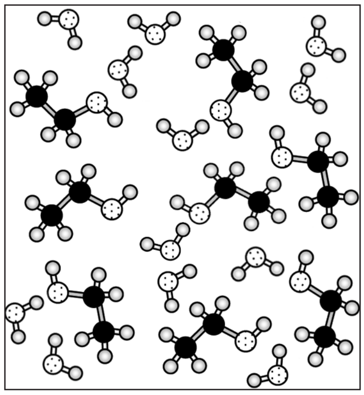


Figure 1

Legend for Figures 1–3:
C – carbon atom ●
O – oxygen atom
H – hydrogen atom ○

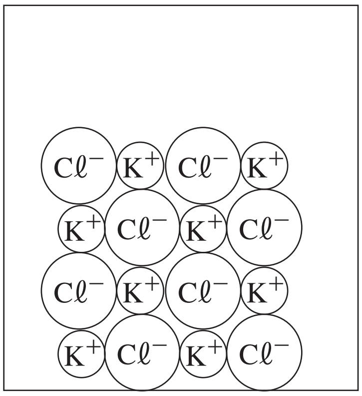


Figure 6

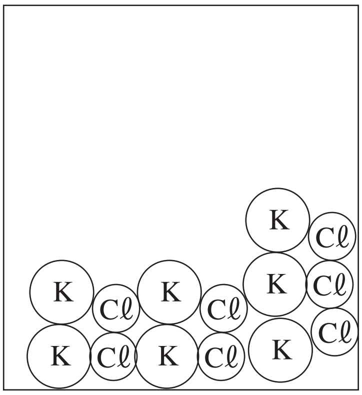


Figure 5

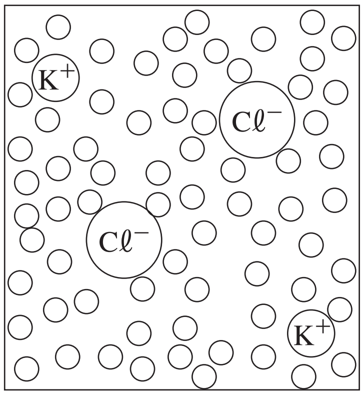


Figure 4

Legend for Figures 4–6:
H_2O – water molecule ○

א. Determine which figure describes the microscopic structure of $C_2H_5OH_{(\ell)}$ at room temperature, and which figure describes the microscopic structure of $KC\ell_{(s)}$ at room temperature.

/continued on page 11/

Potassium chloride was added to a flask containing water, and ethanol was added to another flask containing water. Both substances dissolve well in water.

Dissolving $KC\ell_{(s)}$ produced Solution 1, and dissolving $C_2H_5OH_{(\ell)}$ produced Solution 2.

ב. Write an equation for the process in which $KC\ell_{(s)}$ dissolves in water.

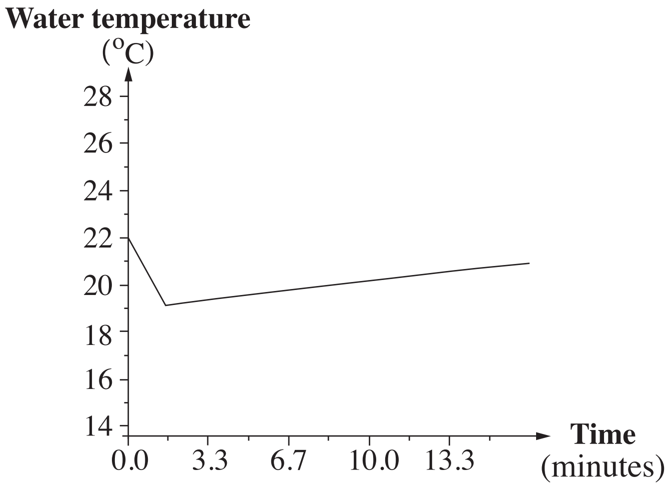
ג. Write an equation for the process in which $C_2H_5OH_{(\ell)}$ dissolves in water.

ד. Which of the solutions, Solution 1 or Solution 2, conducts electricity? Explain why the solution you chose is conductive.

In an experiment, researchers dissolved 0.2 moles of $KC\ell_{(s)}$ in 200 ml of water in a flask that was <u>not thermally insulated</u>. The initial water temperature before $KC\ell_{(s)}$ dissolution was 22°C .

Graph 1, below, describes the change in water temperature during and after dissolution.

Graph 1: Water temperature during and after $KC\ell_{(s)}$ dissolution



Consider the following energy diagrams, a and b .

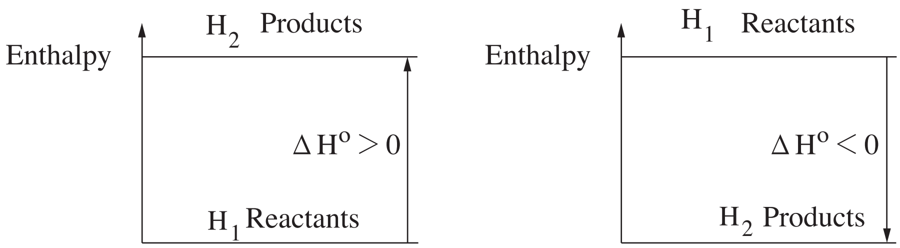


Diagram b **Diagram a**

ה. Which diagram, a or b , correctly describes the change in energy in the process of dissolving $KC\ell_{(s)}$ in water? Explain your choice based on Graph 1.

The substance cyclohexane, $C_6H_{12(\ell)}$, was poured into two flasks, and then $KC\ell_{(s)}$ was added to one flask and $C_2H_5OH_{(\ell)}$ was added to the other flask.

Each flask was stirred to mix the substances it contained.

Only one of the substances dissolved in the cyclohexane. The obtained solution was not conductive.

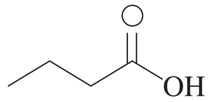
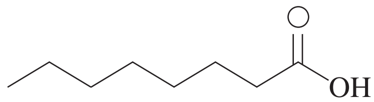
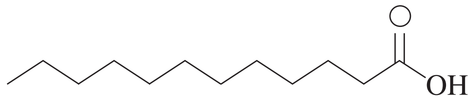
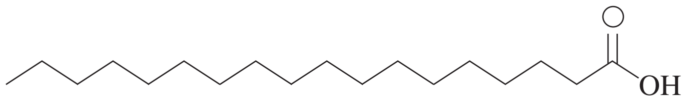
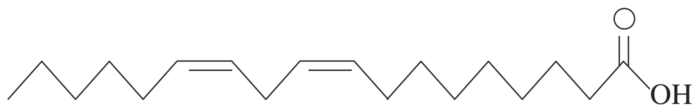
ו. Which of the two substances dissolved? Explain why.

ז. Write an equation for the process of dissolution in cyclohexane.

/continued on page 12/

Fatty Acids

12. The following table presents several fatty acids:

Fatty acid	Symbol	Abbreviated structural formula of the molecule	Melting point (ºC)
Butyric acid	B		− 5.7
Caprylic acid	Oc		16.3
Lauric acid	La		43.8
Stearic acid	S		69.3
Linoleic acid	L		− 5.9

א. Give the abbreviated notation [רישום מקוצר] for each of the fatty acids presented in the table.

ב. What factor causes the melting point of linoleic acid (L) to be lower than the melting point of stearic acid (S)?

Capric acid, whose symbol is D, is a saturated fatty acid that contains 10 carbon atoms.

ג. Give the abbreviated structural formula [ייצוג מקוצר] of a capric acid molecule.

ד. Using the data in the table to help you, **determine** whether the melting point of capric acid is 4°C or 31.6°C .

Name the factor on which you based your answer.

ה. When hydrogen, $H_{2(g)}$, is added to linoleic acid in the presence of a suitable catalyst, the product of the reaction is stearic acid.

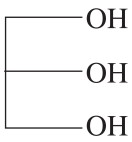
How many moles of hydrogen, $H_{2(g)}$, are required for a complete reaction with 1 mole of linoleic acid? Explain your answer.

/continued on page 13/

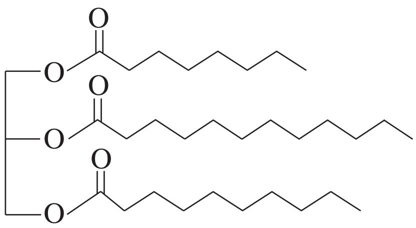
ו. Coconut oil is rich in triglycerides composed of saturated fatty acids that have medium-length carbon chains.

One example is the trigeliceride OcLaD , which is the product of a reaction between glycerol, caprylic acid, lauric acid, and capric acid.

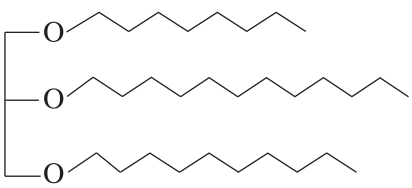
The abbreviated structural formula of a molecule of glycerol is shown below:



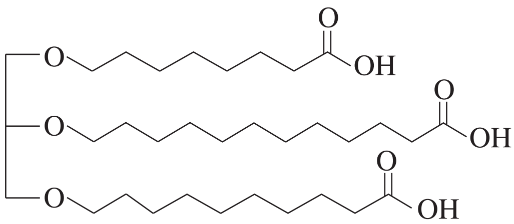
Of the three abbreviated structural formulas (1)-(3), below, which one correctly represents the structural formula of a molecule of the triglyceride OcLaD?



(1)

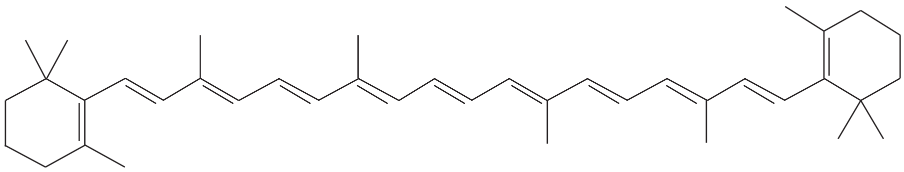


(2)



(3)

ז. One of the substances in fresh pasture grass is a yellow-orange substance called beta-carotene. The abbreviated structural formula of a beta-carotene molecule is shown below:



Butter made from the milk of cows that feed on fresh pasture grass is yellow, because this milk contains the substance beta-carotene. Butter contains about 81% percent fats, about 18% water, and other substances.

Does beta-carotene dissolve in the fats or in the water in butter? Explain your answer. In your answer, discuss the forces that operate between the molecules.

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Oxydation-Reduction, Stoicheometry (Calculations)

13. This question discusses two experiments.

Experiment 1:

There are 3 test tubes, 1-3, in this experiment:

Test tube 1 contains a solution of chlorine ions, $C\ell^-_{(aq)}$, and sodium ions, $Na^+_{(aq)}$.

Test tube 2 contains a solution of bromine ions, $Br^-_{(aq)}$, and sodium ions, $Na^+_{(aq)}$.

Test tube 3 contains a solution of iodine ions, $I^-_{(aq)}$, and sodium ions, $Na^+_{(aq)}$.

A $C\ell_{2(aq)}$ solution was added to each of the test tubes.

The following figures describe test tubes 1-3 before and after the $C\ell_{2(aq)}$ solution was added:

Figure 1:
Test tubes 1–3 before adding $C\ell_{2(aq)}$ solution

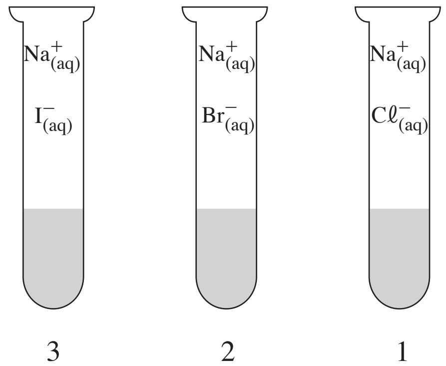
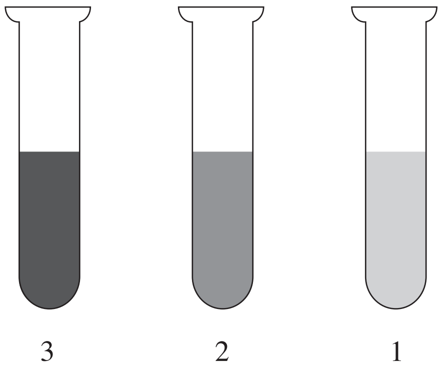


Figure 2:
Test tubes 1–3 after adding $C\ell_{2(aq)}$ solution



א. Based on Figure 2, describe one observation about each test tube after the $C\ell_{2(aq)}$ solution was added.

In this experiment, reactions occurred in only two of the three test tubes.

The following equations describe the net reactions during this experiment:

Reaction I: $C\ell_{2(aq)} + 2I^-_{(aq)} \longrightarrow I_{2(aq)} + 2C\ell^-_{(aq)}$

Reaction II: $C\ell_{2(aq)} + 2Br^-_{(aq)} \longrightarrow Br_{2(aq)} + 2C\ell^-_{(aq)}$

ב. Determine the oxidation level of each one of the particles in the two reactions.

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ג. Consider the following two statements, (1) and (2), about the reactions that took place.
Determine whether each statement is correct or incorrect.
Explain each of your answers.
(1) The oxidizer in both reactions, I and II, is $C\ell_{2(aq)}$.
(2) The reducer in both reactions, I and II, is $C\ell^-_{(aq)}$.

At the end of the experiment the volume of the solution in the Reaction II test tube was 5 ml.
At the end of the reaction, the concentration of chlorine ions, $C\ell^-_{(aq)}$, was 0.1M.

ד. How many **molecules** of bromine, $Br_{2(aq)}$, were obtained in the reaction? Provide detailed calculations.
Given: There are 6.02×10^{23} particles in 1 mole.

Experiment 2:
In this experiment, the researchers set fire to some iron wool, which is composed mainly of solid iron, $Fe_{(s)}$.
In the resulting reaction, $Fe_{(s)}$ reacts with oxygen in the air, $O_{2(g)}$, and produces **iron oxide** which is a solid **ionic compound**.
Iron atoms form two types of ions: Fe^{2+} and Fe^{3+}, so there are two possible iron oxide compounds, one compound for each ion.

ה. Provide the formulas of the two possibilities of iron oxide at room temperature.

In the experiment described above, the researcher obtained an ionic solid in which the iron ion was Fe^{3+}.

ו. Write a balanced equation for the reaction that took place in this experiment.

ז. Is the reaction you wrote an oxidation-reduction reaction?
If it is, determine which substance is the oxidizer and which is the reducer. If not, explain your answer.

ח. In this experiment, 9.8 grams of iron wool, $Fe_{(s)}$, reacted with oxygen, $O_{2(g)}$, according to the reaction you wrote in Item ו.
What is the mass of the iron oxide that was obtained in this reaction? Provide detailed calculations.

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Acids and Bases

14. The following table presents data about four aqueous solutions (1)-(4). All the solutions are colorless.

Solution	**Formula of the substance placed in the water**	**Solution volume** (ml)	**Solution concentration** (M)
(1)	$KOH_{(s)}$	100	1
(2)	$Ba(OH)_{2(s)}$	100	1
(3)	$HC\ell_{(g)}$	100	1
(4)	$H_2SO_{4(\ell)}$	100	1

א. Write an equation for the processes that takes place when each of the substances shown in the table is placed in water:

$KOH_{(s)}$, $Ba(OH)_{2(s)}$, $HC\ell_{(g)}$, $H_2SO_{4(\ell)}$

ב. Rank solutions (1)-(4) in order of their pH, from low to high.

ג. 100 ml of distilled water was added to each of the solutions.
Determine whether each of the statements I and II is correct or incorrect.
Explain each answer.

I The concentration of the solutions changed.

II The ranking order of the solutions (by pH) changed.

The following table presents information about the color of three indicators at different pH values.

Color of indicators at different pH values

Indicator	**pH 0**	**pH 2**	**pH 4**	**pH 7**	**pH 10**	**pH 12**	**pH 14**
Cabbage water	Red	Red	Pink	Blue	Green	Green	Yellow
Phenolphthalein	Colorless	Colorless	Colorless	Colorless	Pink	Pink	Pink
Methyl orange	Red	Red	Orange	Yellow	Yellow	Yellow	Yellow

ד. Use the information in the table to determine whether each of the statements I-III is correct or incorrect. Explain each of your answers.

I Phenolphthalein is an indicator that allows us to identify which of the solutions (1)-(4) are alkaline (basic).

II We can distinguish between Solution (2) and Solution (3) using cabbage water indicator.

III We can distinguish between Solution (1) and Solution (2) using the indicator methyl orange.

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The solutions were mixed as described in the table below, and a reaction took place in each mixture.

Given: All the potassium compounds are highly soluble (miscible, קל-תמס), but barium sulfate, $BaSO_{4(s)}$, is an insoluble (immiscible, קשה-תמס) white substance.

ה. Answer both questions for each of the experiments, I-IV, below:

- What is the pH range of the solution after mixing?
- Is the solution conductive [מוליכה חשמל] after mixing?

Experiment no.	Solutions in the mix	Observed after mixing	pH range of the solution after mixing (acidic, alkaline, or neutral)	Electrical conductivity after mixing (conductive or not conductive)
I	(1) and (3)	The solution is clear		
II	(1) and (4)	The solution is clear		
III	(2) and (3)	The solution is clear		
IV	(2) and (4)	A white sediment		

ו. The reactions that took place in experiments I-III have the same net equation. Write this equation.

ז. Choose the equation from Equations **(1)-(3)** which represents the reaction that took place in Experiment IV .

(1) $Ba^{2+}_{(aq)} + 2OH^{-}_{(aq)} + 2H_3O^{+}_{(aq)} + SO^{2-}_{4(aq)} \longrightarrow Ba^{2+}_{(aq)} + SO^{2-}_{4(aq)} + 4H_2O_{(\ell)}$

(2) $Ba(OH)_{2(aq)} + H_2SO_{4(\ell)} \longrightarrow BaSO_{4(s)} + 2H_2O_{(\ell)}$

(3) $Ba^{2+}_{(aq)} + 2OH^{-}_{(aq)} + 2H_3O^{+}_{(aq)} + SO^{2-}_{4(aq)} \longrightarrow BaSO_{4(s)} + 4H_2O_{(\ell)}$

Good Luck!

בהצלחה!