

State of Israel
Ministry of Education

Exam Type: *Bagrut*
Exam date: Summer 2025
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"ה, 2025
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

הוראות

א. Duration of the exam: Three hours

א. משך הבחינה: שלוש שעות.

ב. Exam structure and breakdown of points:

ב. מבנה השאלון ומפתח ההערכה:

This exam has two parts.

בשאלון זה שני פרקים.

Part One – 40 points

פרק ראשון – 40 נקודות

Part Two – 60 points

פרק שני – 60 נקודות

Total – 100 points

סך הכול – 100 נקודות

ג. Material that may be used during the exam:

ג. חומר עזר מותר בשימוש:

(1) A calculator (graphing calculators are permitted)

(1) מחשבון (כולל מחשבון גרפי).

(2) Formula and data sheets (attached)

(2) דפי נוסחאות ונתונים (מצורפים).

(3) A Hebrew–foreign language/
foreign language–Hebrew dictionary

(3) מילון עברי–לועזי / לועזי–עברי.

ד. Special instructions:

ד. הוראות מיוחדות:

(1) In Part One, there are nine questions.

(1) בפרק הראשון יש תשע שאלות.

For each of Questions 1–8, four possible answers are presented and you must choose the correct answer.

בכל אחת מן השאלות 1–8 מוצגות ארבע תשובות, ומהן יש לבחור בתשובה הנכונה.

Mark the correct answers on the answer sheet at the end of the answer booklet (page 23).

את התשובות הנכונות יש לסמן בתשובון שבסוף מחברת הבחינה (עמוד 23).

Answer the items in Question 9 according to the instructions.

בשאלה 9 יש לענות על הסעיפים לפי ההנחיות.

(2) In Part Two, there are five questions.

(2) בפרק השני יש חמש שאלות. יש לענות על שלוש מהן.

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.

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

Good Luck!

בהצלחה!

Questions

Part One (40 points)

Answer **all** eight questions 1–8 (20 points).

If you answer at least six questions correctly, you will receive the full 20 points.

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

Four answers are suggested for each question. Choose the correct answer.

- * Mark the answer you chose on the answer sheet at the end of the answer booklet (page 23).
- * For each question, use a pen to mark an $\times$ in the box below the letter (א–ד) that represents the answer you chose.
- * Mark an $\times$ 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. The following table lists the names and formulas of substances.

The Particles column lists types of particles.

Which of the options א–ד describes a correct match between a substance and the particles of which it is made?

	Substance	Particles
א.	Silicon, $\text{Si}_{(s)}$	Silicon molecules
ב.	Potassium, $\text{K}_{(s)}$	Positive potassium ions and negative potassium ions
ג.	Sulfur dioxide, $\text{SO}_{2(g)}$	Sulfur atoms and oxygen molecules
ד.	Magnesium chloride, $\text{MgCl}_{2(s)}$	Positive magnesium ions and negative chlorine ions

2. This question is about the atoms of three elements located in the third row (third period) of the periodic table.

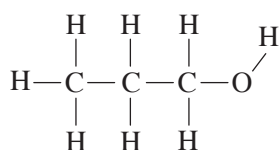
We label these atoms X, Y, and Z.

We know that the atomic radius of X $>$ the atomic radius of Y $>$ the atomic radius of Z.

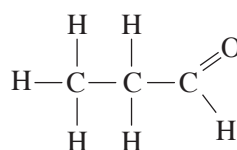
Which of the following statements is correct?

- א. The nuclear charge of an atom of element X is the greatest.
- ב. The first ionization energy of element X is the greatest.
- ג. The number of valence electrons [אלקטרוני הערכיות] in an atom of element Z is the greatest.
- ד. The electronegativity of an atom of element Y is the greatest.

3. Consider the full structural formula of molecules of two substances:



(II) Propanol molecule

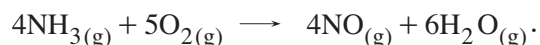


(I) Propanal molecule

Which of the following statements is correct?

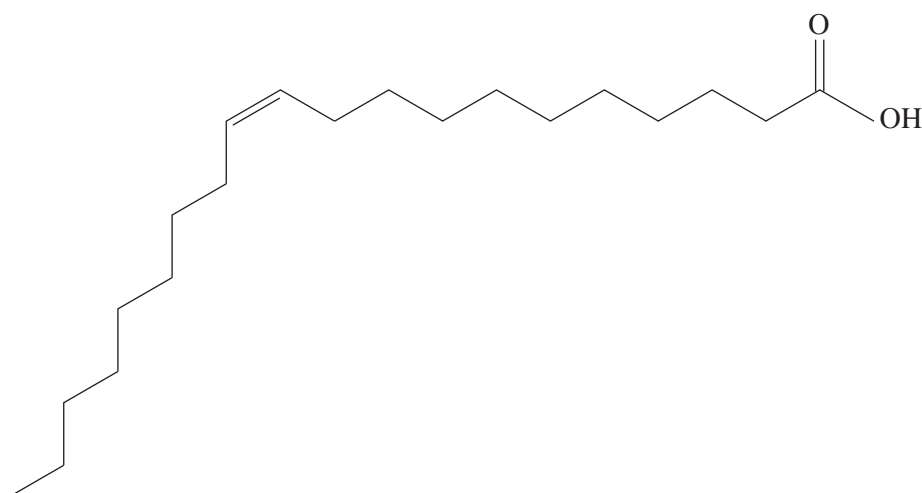
- א. Propanal (I) has a higher boiling point, because there are stronger van der Waals interactions between propanal molecules.
- ב. Propanal (I) has a higher boiling point, because its molecules have a double bond $\text{C}=\text{O}$.
- ג. Propanol (II) has a higher boiling point, because its molecules have a smaller electron cloud.
- ד. Propanol (II) has a higher boiling point, because its molecules form hydrogen bonds between them.
4. An aqueous solution of aluminum chloride, $\text{AlCl}_{3(\text{aq})}$, contains 2.67 grams of solute.
How many moles of ions are there **in total** in the solution?
- א. 0.02 moles
- ב. 0.04 moles
- ג. 0.06 moles
- ד. 0.08 moles
5. 100 ml of 0.1M barium hydroxide solution, $\text{Ba}(\text{OH})_{2(\text{aq})}$, were mixed with 100 ml of an aqueous acid solution.
The resulting titration reaction was complete. The pH measured at the end of the reaction was $\text{pH} = 7$.
Which of the following solutions א–ד is the aqueous acid solution?
- א. 0.4M solution of $\text{HNO}_{3(\text{aq})}$
- ב. 0.2M solution of $\text{HNO}_{3(\text{aq})}$
- ג. 0.4M solution of $\text{H}_2\text{SO}_{4(\text{aq})}$
- ד. 0.2M solution of $\text{H}_2\text{SO}_{4(\text{aq})}$

6. Consider the following equation of the reaction between ammonia and oxygen:



Which of the following statements is correct?

- א. The hydrogen atoms in $\text{NH}_{3(g)}$ underwent reduction.
 - ב. The nitrogen atoms in $\text{NH}_{3(g)}$ underwent reduction.
 - ג. The oxygen atoms underwent reduction.
 - ד. The electrons in the reaction passed from the oxygen atoms to the hydrogen atoms.
7. Consider the following abbreviated structural formula of gondoic acid, a fatty acid present in jojoba oil:



Which of the following statements is correct?

- א. The abbreviated notation of one of the isomers of gondoic acid is $\text{C}_{20}:1\omega7$ cis .
- ב. Gondoic acid belongs to the omega-6 group of fatty acids.
- ג. The abbreviated notation of gondoic acid is $\text{C}_{20}:1\omega9$ trans .
- ד. Gondoic acid is a polyunsaturated acid.

8. Students wanted to investigate the reaction that occurs when hydrogen peroxide, $\text{H}_2\text{O}_{2(\text{aq})}$, in solution breaks down.

The students put 10 ml of 0.88M (3%) $\text{H}_2\text{O}_{2(\text{aq})}$ solution in a test tube and kept it at room temperature.

Consider the given reaction: $2\text{H}_2\text{O}_{2(\text{aq})} \longrightarrow 2\text{H}_2\text{O}_{(\ell)} + \text{O}_{2(\text{g})}$

The students suggested some changes to increase the reaction rate.

Which of the suggestions א-ד would increase the reaction rate?

- א. doubling the volume of hydrogen peroxide in the test tube to 20 ml
- ב. doubling the concentration of hydrogen peroxide in the test tube to 1.76M (6%)
- ג. reducing the temperature of the hydrogen peroxide in the test tube to 15°C
- ד. increasing the surface area of the solution by transferring the hydrogen peroxide into an Erlenmeyer flask

Analysis of a passage from a scientific article – Required

9. Read the following passage and answer the items that follow, as directed

(required question – 20 points).

Searching for life in the solar system

Scientists estimate that life on Earth emerged about 3.8 billion years ago. They base this estimate on scientific methods that use the decay processes of radioisotopes to determine the age of fossils and rock.

Several theories exist to explain how life emerged on Earth. According to one, the essential complex molecules found in living organisms were formed from smaller molecules that once existed in Earth's atmosphere. In 1953, the researchers Miller and Urey ran an experiment which provided the first evidence supporting this theory.

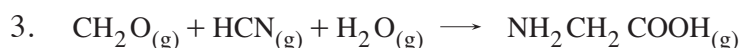
In the Miller-Urey experiment, the researchers filled a flask with a mixture of gases they knew was similar to the mixture present in Earth's atmosphere when life first emerged, based on knowledge available to them at the time. The mixture contained chiefly water, $\text{H}_2\text{O}_{(g)}$, and also ammonia, $\text{NH}_3_{(g)}$, methane, $\text{CH}_4_{(g)}$, and hydrogen, $\text{H}_{2(g)}$.

Based on the accepted assumption that lightning was an energy source in this early era, the experimental flask was supplied with energy by passing an electrical current through the mixture, simulating the effect of lightning. The researchers examined the products of the experiment after one week, and found many carbon compounds such as fats, and also molecules of glycine, $\text{NH}_2\text{CH}_2\text{COOH}$.

Reactions 1 and 2 below are some of the reactions that took place in the experiment:



The products of Reactions 1 and 2 reacted further in Reaction 3 below to form glycine.



The glycine molecule is one of the building blocks of proteins, which are characteristic of living cells. The results of the Miller-Urey experiment showed that, in the presence of water, it is possible to produce complex molecules from the simpler molecules that had probably been present in Earth's early atmosphere.

Earth is the only planet in the solar system on which we know that life emerged.

Scientists are searching for planets or moons with similar climates and temperatures to Earth.

Water and water-soluble substances could provide suitable conditions for life to develop, which is why current efforts are concentrating on looking for water on the surfaces of planets and moons.

(Continued on the next page.)

In October 2024, the Europa Clipper probe was sent to Europa, a moon of planet Jupiter, the largest planet in the solar system. Europa shows strong evidence of a huge ocean of liquid water beneath its icy crust. There is further evidence that this water conducts electricity. Europa Clipper was launched to determine whether conditions in this ocean could support the development of life.

The spacecraft has a vault with walls made of 1 cm thick sheets of an aluminum titanium alloy to protect it from Jupiter's radiation. It is expected to reach its destination in 2030, and will broadcast data as it orbits Europa for four years. We must wait a few more years for an answer to our question: Are there life-supporting conditions elsewhere in the solar system?

Adapted chiefly from:

<https://europa.nasa.gov/why-europa/ingredients-for-life/>

https://en.wikipedia.org/wiki/Miller%E2%80%93Urey_experiment

Answer all the items א, ב, ג, ד, ה, and ו, and one of the items ז or ח.

- א. One of the methods for determining the age of rock and fossils uses information obtained from the decay of $^{235}_{92}\text{U}$, the radioactive isotope of uranium.

The decay of the radioactive isotope $^{235}_{92}\text{U}$ is shown below:



A is an arbitrary symbol for the isotope.

- (1) What is the atomic number of A ?
- (2) What is the mass number of A ?
- (3) What is the element symbol of A ?

- ב. Copy the following table to your answer booklet and fill in the missing information.

Substance in Reactions 1 and 2	$\text{H}_2\text{O}_{(\text{g})}$	$\text{CH}_{4(\text{g})}$	$\text{CH}_2\text{O}_{(\text{g})}$	$\text{H}_{2(\text{g})}$	$\text{NH}_{3(\text{g})}$	$\text{HCN}_{(\text{g})}$
Molecular formula	H_2O					
Electron dot structure of the molecule						
Molecular shape	angular	tetrahedron	triangular planar	linear	triangular pyramid	linear
Polarity of the molecule polar / non-polar						

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

- ג. Consider the following data:

The oxidation level of the carbon atom in the molecule CH_4 is (-4) .

The oxidation level of the carbon atom in the molecule CH_2O is (0) .

- (1) Does the oxidation level of the hydrogen atoms in Reaction 1 change, and, if so, in what way?
- (2) Does the oxidation level of the oxygen atoms in Reaction 1 change, and, if so, in what way?
- ד. What are the names of the functional groups in a molecule of glycine?
- ה. The following figures describe models of two molecules. Determine which figure, 1 or 2, describes an isomer of a glycine molecule, and explain your answer. In your answer, discuss the term *isomer*.

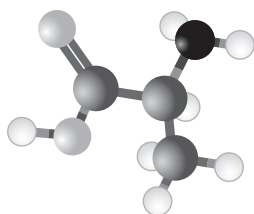


Figure 2

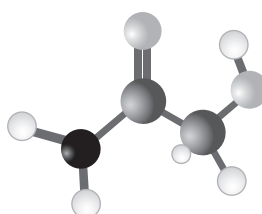


Figure 1

Legend:	
Carbon	
Hydrogen	
Oxygen	
Nitrogen	

- ו. Researchers repeated the Miller-Urey experiment. We know that 0.001 moles of ammonia reacted in this experiment.

Calculate how many molecules of glycine were obtained in the reaction.

Provide detailed calculations. Assume that the reaction was complete.

Item ו is an optional item. If you choose to answer it, do not answer Item ה.

- ז. Based on the reactions in the passage, explain why the researchers continuously supplied the flask in the Miller-Urey experiment with energy throughout the experiment.

Item ה is an optional item. If you choose to answer it, do not answer Item ו.

- ח. Based on the passage, determine what type of particle might be present in the ocean under the ice crust of Europa, other than water molecules.

Part Two (60 points)

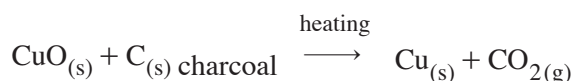
Answer three of the questions 10–14 (each question – 20 points).

Structure and Bonding, Stoichiometry (calculations)

10. Copper, $\text{Cu}_{(s)}$, is a shiny, reddish-orange metal. According to archaeological findings, people have been extracting copper from copper-containing ore since 3,000 BCE (ore is a mixture of minerals found in the ground).

In the past, copper was extracted from copper oxide, $\text{CuO}_{(s)}$, found in ore, and charcoal, $\text{C}_{(s)}$, was used in the process. Copper oxide and charcoal are both black.

Consider the following unbalanced equation of the reaction:



- א. Copy the equation to your answer booklet and balance it.
- ב. Name one macroscopic change that could indicate that a reaction took place.

The table below shows data for two substances in the reaction.

Substance symbol	Electrical conductivity in solid state	Electrical conductivity in liquid state
A	✓	✓
B	×	✓

- ג. Determine which of the substances in the reaction is Substance A and which is Substance B.
- ד. Select one of the substances you identified in Item ג, and explain the electrical conductivity data for this substance in solid state and in liquid state.
- ה. In 1 metric ton of a given ore there is 92% copper oxide, $\text{CuO}_{(s)}$, by mass.
Copper was extracted from the copper oxide in the ore according to the reaction you balanced in Item א.
Calculate how many moles of the gas $\text{CO}_{2(g)}$ were released. Provide detailed calculations.
Given: 1 metric ton = 1×10^6 gram

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

The excess of $\text{CO}_{2(g)}$ gas that is emitted into the atmosphere increases the greenhouse effect and global warming. Modern industry has found methods of capturing $\text{CO}_{2(g)}$ to prevent it from being discharged into the atmosphere. One of these methods includes a reaction of the gas $\text{CO}_{2(g)}$ with a substance called MEA, and then separation of the products by dissolving in water.

1. The abbreviated structural formula of an MEA molecule is $\text{HOCH}_2\text{CH}_2\text{NH}_2$.

We know that the substance MEA is water soluble.

Consider the four figures 1–4, below.

Determine which of the four figures 1, 2, 3, 4 is a correct description of a hydrogen bond between an MEA molecule and a water molecule.

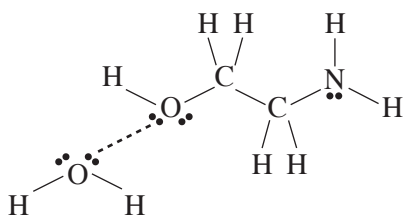


Figure 2

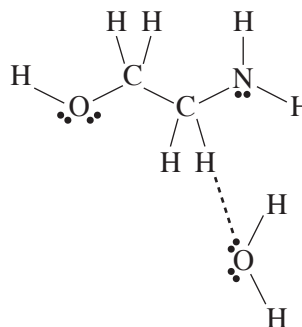


Figure 1

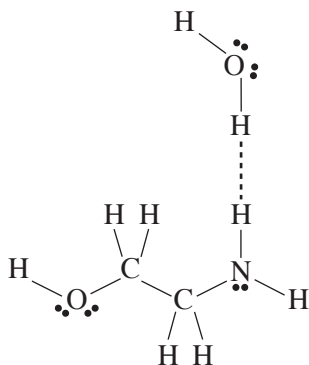


Figure 4

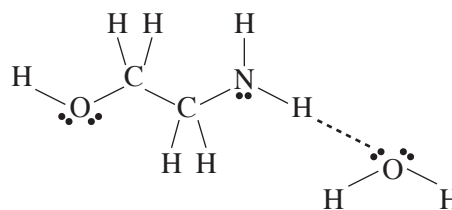
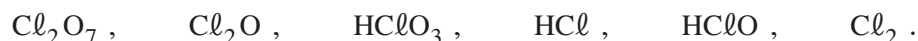


Figure 3

Oxidation-Reduction, Stoichiometry (calculations)

11. א. Consider the formulas of the following six molecules:



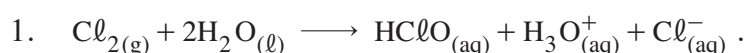
(1) Determine the oxidation level of the chlorine atom in each of these molecules.

(2) Determine in which of these molecules the chlorine atoms could undergo both oxidation and reduction. Explain your answers.

Adding the gas chlorine, $\text{Cl}_{2(\text{g})}$, to water is a way to disinfect the water.

The reaction between water and chlorine gas produces hypochlorous acid, $\text{HClO}_{(\text{aq})}$, which disinfects the water.

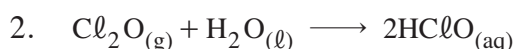
Consider Reaction 1:



א. Determine which substance is the oxidizer and which substance is the reducer in Reaction 1. Explain both answers.

We can also produce hypochlorous acid in a different process, by dissolving dichlorine monoxide, $\text{Cl}_2\text{O}_{(\text{g})}$, in water.

Consider Reaction 2:



א. Is Reaction 2 an oxidation–reduction reaction? Explain your answer.

The solution of sodium hypochlorite (bleach), $\text{NaClO}_{(\text{aq})}$, is used as a disinfectant and whitener.

א. Formulate the reaction of the dissolution of $\text{NaClO}_{(\text{s})}$ in water.

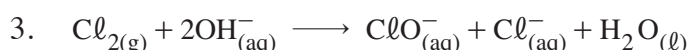
ב. 30 grams of $\text{NaClO}_{(\text{s})}$ were dissolved in water, and a 1 liter solution of sodium hypochlorite was prepared.

Calculate the molar concentration of the resulting $\text{NaClO}_{(\text{aq})}$ solution.

Provide detailed calculations.

ג. A solution of sodium hypochlorite can also be made by adding gaseous chlorine, $\text{Cl}_{2(\text{g})}$, to a solution of sodium hydroxide, $\text{NaOH}_{(\text{aq})}$.

Consider the equation for the net reaction:



$\text{Cl}_{2(\text{g})}$ was added to 4 liters of a 2M $\text{NaOH}_{(\text{aq})}$ solution. The substances reacted completely (the solution's volume did not change).

(1) Calculate the mass of the gaseous chlorine, $\text{Cl}_{2(\text{g})}$, that reacted.

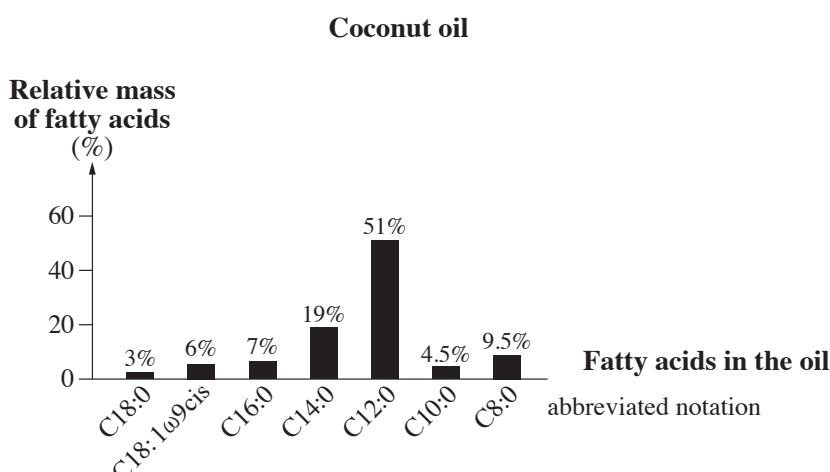
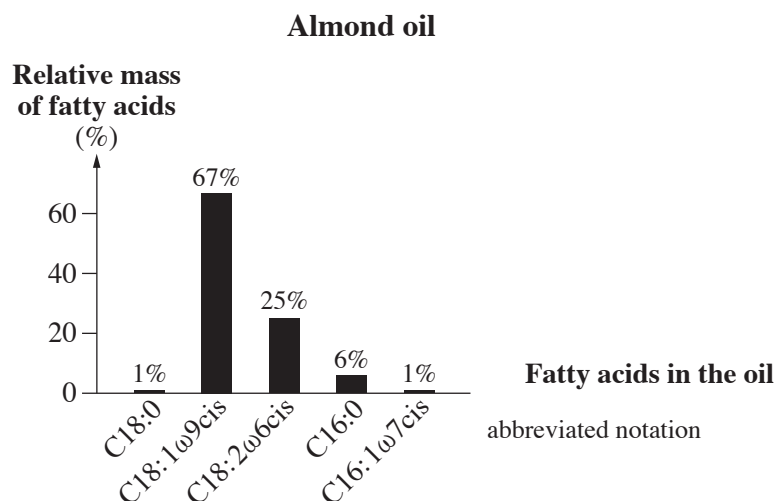
Provide detailed calculations.

(2) Calculate the concentration of $\text{ClO}_{(\text{aq})}^-$ ions in the obtained solution.

Provide detailed calculations.

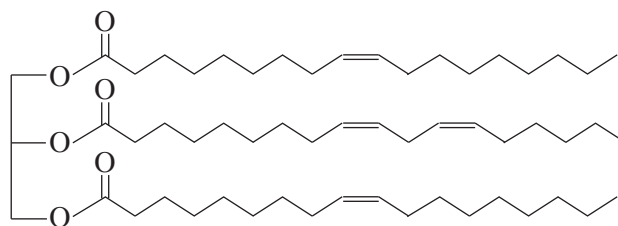
Structure and Bonding, Food Chemistry

12. Almond oil and coconut oil are both used in body massage. Both oils are composed of triglycerides. Consider the following information about the fatty acids that compose the triglycerides in these oils.



- א. (1) Provide the abbreviated notation of the most common fatty acid in almond oil, and the abbreviated notation of the most common fatty acid in coconut oil.
- (2) Provide the abbreviated structural formula for each of the fatty acids you listed in Sub-Item (1).
- (3) Provide the molecular formula for each of the fatty acid molecules you listed in Sub-Item (1).
- (4) The melting point of the most common fatty acid in almond oil is lower than the melting point of the most common fatty acid in coconut oil.
- What is the main cause of this difference?
- ב. A complete hydrogenation reaction of 100 grams of **coconut oil** was performed.
- (1) Provide the molecular formula for the fatty acid that reacted in the hydrogenation reaction.
- (2) Based on the data in the graph, determine the mass of the substance that reacted in the hydrogenation reaction.
- (3) Calculate how many **moles** of hydrogen, $H_{2(g)}$, were required in the hydrogenation reaction. Provide detailed calculations.

- ג. The abbreviated structural formula of a molecule of a given triglyceride is shown below. This triglyceride can be found in only **one** of the two oils.

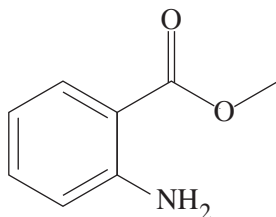


Determine in which of the two oils, almond oil or coconut oil, molecules of this triglyceride might be present. Explain your answer.

- ד. In aromatherapy massage therapists use oils like coconut oil or almond oil together with essential oils.

One such essential oil is produced from the jasmine plant. This oil contains several different molecules.

Below is the abbreviated structural formula of Molecule A, one of the molecules composing this essential oil.



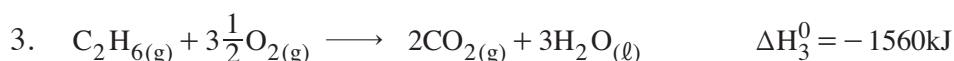
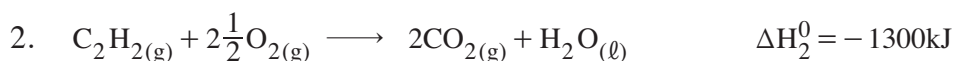
Molecule A

- (1) Draw the full structural formula of Molecule A.
- (2) Name all the functional groups in Molecule A.
- (3) Explain why Molecule A is soluble in both water and coconut oil.

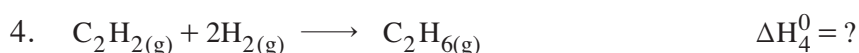
Structure and Bonding, Energy

13. Consider the combustion reactions of three substances and their respective ΔH^0 values.

The substances: hydrogen, $H_{2(g)}$, acetylene, $C_2H_{2(g)}$, ethane, $C_2H_{6(g)}$.



Consider the given Reaction 4 for producing ethane from acetylene and hydrogen.



א. Calculate the value of ΔH_4^0 .

ב. (1) Draw the full structural formula for a molecule of C_2H_2 , and the full structural formula for a molecule of C_2H_6 .

(2) List the three types of covalent bonds that a carbon atom forms in these molecules.

ג. The following table shows bond enthalpy values for the types of bonds present in the molecules in Reaction 4.

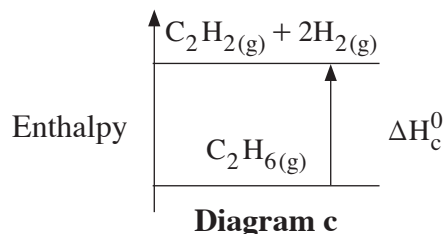
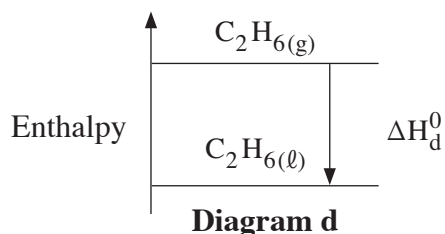
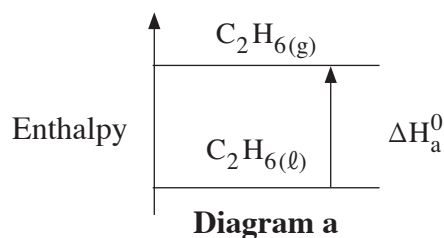
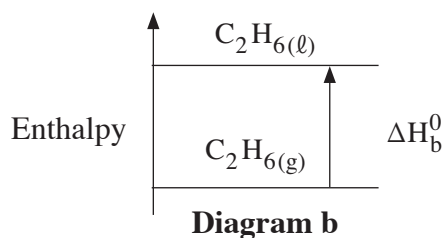
Bond enthalpy ($\frac{\text{kJ}}{\text{mol}}$)	436	346	413	835
Enthalpy bond symbol	$\Delta H_{(H-H)}$			
Covalent bond	H-H			

(1) Copy the table to your answer booklet.

Fill in the missing information in the blank cells in the table. Make sure to give the correct bond for each of the values.

(2) Select two bonds created by the carbon atom which you listed in the table, and state the cause(s) for the difference in their bond enthalpy values.

7. Provide the **expression** used to calculate ΔH_4^0 using bond enthalpy symbols, **without calculating it**.
- ה. Below are four energy diagrams, a , b , c , and d .



Determine which of the diagrams a , b , c , or d correctly describes the change in energy during the evaporation of ethane.

Explain your answer. In your explanation, discuss interactions between particles.

1. Draw the correct energy diagram for Reaction 4 in your answer booklet. In the diagram you drew, insert the correct value of ΔH_4^0 .

Acids and Bases

14. Some students were asked to identify four white, easily soluble solid substances. The solids were labeled A , B , C , D .

The students conducted two experiments to identify the solid substances.

Experiment 1

The students received clear, colorless 1M solutions of the substances A , B , C , and D .

They added a few drops of cabbage water indicator to each of the solutions.

The solution colors obtained in **Experiment 1** are shown in the following table.

Results of Experiment 1

Solute	Solid A	Solid B	Solid C	Solid D
Solution color after adding cabbage water	Blue-purple	Green	Red	Yellow

The following table shows the color of the cabbage water indicator at various pH levels.

Color of cabbage water indicator at various pH levels

	pH 0	pH 2	pH 4	pH 7	pH 10	pH 12	pH 14
Cabbage water	red	red	pink	blue-purple	green	green	yellow

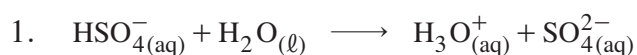
- ⌘. Based on the results of Experiment 1, sort the solutions of substances A , B , C , and D into three groups: acid solutions, basic solutions, and solutions that are neither acid nor basic. Explain your answer.

These are the four substances that the students were asked to identify:

- Sodium chloride, $\text{NaCl}_{(s)}$
- Sodium hydroxide, $\text{NaOH}_{(s)}$
- Sodium hydrogencarbonate, $\text{NaHCO}_{3(s)}$
- Sodium hydrogensulfate, $\text{NaHSO}_{4(s)}$

These substances are ionic compounds.

- ⌘. Formulate the dissolution reaction of $\text{NaCl}_{(s)}$ in water and the dissolution reaction of $\text{NaOH}_{(s)}$ in water.
- ⌘. Consider the equation of the given net reaction:



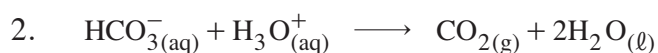
Of the substances that the students were asked to identify, provide the formula of the substance which is acidic in solution. Explain your answer.

Experiment 2

A solution of $\text{HCl}_{(\text{aq})}$ was added to each of the basic solutions. The color of each of these solutions changed.

7. (1) Explain why the basic solutions changed color.
(2) Is it possible to determine what colors were obtained in the solutions at the end of Experiment 2? Explain your answer.
- ה. While adding $\text{HCl}_{(\text{aq})}$ solution a gas was discharged from one of the basic solutions which was green in Experiment 1.

Consider the equation of the net reaction:



Determine which substance had been dissolved in the solution that discharged gas.

- ו. Match each of the solid substances that the students identified with its correct label— A , B , C , D. Explain each answer.

Good Luck!

All rights reserved by the State of Israel.
No part of this document may be copied or disseminated without the permission of the Ministry of Education.

בהצלחה!

זכות היוצרים שמורה למדינת ישראל
אין להעתיק או לפרסם אלא ברשות משרד החינוך